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REPORT OF A WATER QUALITY SURVEY OF HAMPTON ROADS SHELLFISH AREAS

Public Health Service
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REPORT OF A
WATER QUALITY SURVEY
OF
HAMPTON ROADS SHELLFISH AREAS

OCTOBER 11, 1949 TO FEBRUARY 21, 1950

BY

PUBLIC HEALTH ENGINEER RUSSELL S. SMITH

U. S. PUBLIC HEALTH SERVICE

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I

CONCLUSIONS

A survey of the bacterial quality of the waters overlying the shellfish growing areas in and near Hampton Roads was made during the period from October, 1949 to February, 1950.

The following conclusions are drawn from the results obtained during this survey:

1. Despite a large increase in sewered population, the tidal waters of the Hampton Roads area are generally of better bacterial quality than they were in 1934.
2. One area in the James River between Newport News and Hilton Village has a poorer water quality than in 1934. This is due to sewage, which is discharged after passage through an inadequate septic tank, from a population much larger than that of 1934.
3. Water quality in the area should show further improvement when the remaining sources of raw sewage pollution are connected to the treatment plants.
4. The sewage treatment plants can accomplish the purpose for which they were designed and built, and, with some exceptions, were doing so at the time of this survey. Continued careful operation, maintenance and control are essential if the plants are to continue to accomplish the planned function of satisfactorily maintaining a low bacterial density in the waters of the Roads.
5. Potential hazards still exist to the unrestricted use of these waters for shellfish taking. The particular hazard for which no immediate solution is seen is the discharge of raw sewage from ships in the area.

II

ORIGIN AND OBJECTIVES

A. History

The shallow tidal waters of Hampton Roads and the tributary streams, as well as those of the Chesapeake Bay area just outside of Hampton Roads proper, have been an important shellfish growing area for many years. As the port cities around the Roads have increased in population and the adjacent areas have changed from farm lands to sewered residential suburbs, there has been much concern over the resulting pollution that reached the shellfish beds and the possible danger to public health. Several pollutional surveys have been made in this area by both State and Federal agencies. Among the most extensive of these surveys were two made by the U. S. Public Health Service in 1914 and in 1934. The first of these was made as a part of the "Investigation of the Pollution of Tidal Waters of Maryland and Virginia" (Public Health Bulletin 74, 1916). At that time it was concluded that the oyster beds of the Hampton Roads area with the exception of those in Hampton and Mill Creeks and in the Elizabeth River and its tributaries, could be used safely for the taking of market shellfish. However, warning was given that unless remedial measures were taken to "disinfect" sewage discharges by chlorination, it was probable that areas on Hampton Flats, particularly in the vicinity of Salters and Hampton Creeks, would have to be condemned for the taking of market oysters.

A cooperative survey by the Food and Dairy Division of the State Department of Agriculture and the U. S. Public Health Service was made in 1926. This survey was confined to Hampton Flats and Newport News Bar and resulted in restricting the taking of market shellfish from the entire northern section of Hampton Roads and its tributaries from Old Point Comfort to a point northwest of Hilton Village. This action was taken in September, 1926.

In 1933-1934 the results of surveys made between 1926 and 1931 were reviewed and an extensive bacteriological survey of the waters of Hampton Roads was undertaken by the U. S. Public Health Service with the cooperation of the State Department of Health. The results of this investigation are given in a mimeographed report of the Public Health Service "A Study of the Pollution of the Waters of

Hampton Roads and Vicinity and Report on Severage and Sewage Disposal for the Adjacent Communities" issued in December, 1934. This report recommended the building of interceptor sewers to collect the sewage of the various communities and the construction of several plants to treat the sewage by sedimentation and chlorination with separate digestion of the settled solids. It stated that such treatment might possibly allow the reopening of certain shellfish areas then closed, and would improve the physical and bacteriological quality of bathing waters. This report also recommended that a resurvey be made subsequent to the completion of the sewage treatment facilities.

The Hampton Roads Sanitation District Commission was established by Act of the Legislature in 1938 for the purpose of collecting and treating sewage from all areas immediately tributary to the waters of Hampton Roads and also from adjacent portions of the west shore of Chesapeake Bay from Buckroe Beach on the north to Ocean View on the south. In accordance with a provision of the enabling Act, the City of Portsmouth withdrew from the Sanitation District to construct its own sewage treatment facilities. Before plant construction was commenced, war was declared and shortages of labor and material postponed construction of the plant.

War activity in the area caused a large increase in the sewered population tributary to the waters of Hampton Roads. Localized surveys by the Commonwealth of Virginia led, in August, 1944, to declaring the east portion of Craney Island Flats between Hoffler Creek and Norfolk Harbor Channel a restricted area for taking market oysters. Similar action was taken in August, 1946, for certain areas immediately outside the entrance to the Roads. Although these areas were restricted for the taking of market shellfish, they were used for growing oysters for relaying and self purification in approved waters. Large areas were leased from the State by the oyster growing and packing companies at a nominal yearly rental. Seed oysters were purchased, planted on the leased beds and harvested three years later. Under supervision of the State Commission of Fisheries these oysters were relaid in approved waters in Chesapeake Bay and some of its inlets for not less than two weeks, again gathered and then brought to the packing houses. This relaying caused an appreciable loss in oysters between the growing beds and the packing house as well as additional costs in labor and transportation.

After the war the Sanitation District Commission built two plants and acquired one plant constructed during the war by the Federal Government. The last of the four main plants in the area, the one constructed by the City of Portsmouth, commenced operation in the spring of 1949.

B. Present Survey

Following the completion of the sewage treatment plants of the type recommended in 1934 and the interception and treatment of most of the sewage previously discharged raw into the waters of Hampton Roads, insistent questions arose as to whether the plants were fulfilling their purpose in a satisfactory manner. The oyster growers of the area were particularly desirous of knowing if any restricted shellfish areas had improved sufficiently to be opened for unrestricted taking of shellfish. The Hampton Roads Sanitation District Commission desired to know what changes in bacteriological quality of the waters had resulted from plant operation. The general public was perturbed about the safety of certain areas for bathing and sought assurance on this score.

The Virginia Department of Health is responsible for determining the quality of waters in shellfish growing areas and for delineating those areas from which shellfish may be taken for direct marketing and those from which shellfish must be removed to better quality waters before marketing. A survey of the shallow water areas of Hampton Roads, and of certain adjacent areas, was organized to obtain the necessary sanitary and bacteriological data to determine what areas might be used for growing shellfish for direct marketing. The results from this survey were expected to furnish sufficient information for determining whether the sewage treatment plants were accomplishing their intended purpose and to provide a basis for decision concerning the suitability of the shore waters for bathing.

III

ORGANIZATION

The Public Health Service of the Federal Security Agency was requested to aid in the survey. It was organized as a cooperative project between the Commonwealth of Virginia and the Public Health Service. A sanitary engineer was assigned by the Public Health Service to the State Department of Health to direct and coordinate the survey and write the report.

The State Department of Health provided administrative direction and furnished all necessary laboratory supplies, media and equipment, office equipment and supplies, full time use of a large cabin cruiser with operator for sample collection and most of the personnel for the survey.

The Hampton Roads Sanitation District Commission provided laboratory and office space at its Boat Harbor Sewage Treatment Plant in Newport News, furnished from its records available information concerning sanitary conditions, made frequent routine bacteriological examinations of its sewage treatment plant effluents and furnished records of plant operations.

The Virginia Commission of Fisheries made one of its patrol boats with crew available for sample collecting two mornings a week to augment sampling by the State Department of Health boat.

The City of Portsmouth made bacteriological examinations of its sewage treatment plant effluent as frequently as the City Health Department laboratory facilities would permit and furnished records of plant operation.

The survey personnel consisted of the following:

Public Health Engineer Russell S. Smith, Public Health Service
Bacteriologist William G. Gay, Virginia Department of Health
Bacteriologist (temp.) Arthur J. Weiner, Virginia Department of Health
Laboratory Technician (temp.) Dorothy Kirl, Virginia Department of Health
Shellfish Sanitarian (temp.) Richard Keever, Virginia Department of Health
Clerk-Typist (temp.) Marian Pittman, Virginia Department of Health

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Laboratory Aide (temp.) Nick Morent, Virginia Department of Health
Boat Operator M. L. Thomas, Virginia Department of Health
Boat Operator (part time) C. L. Thompson, Virginia Comm. of Fisheries
Asst. Boat Oper. (part time) W. W. Thomas, Virginia Comm. of Fisheries

For purposes of record and identification, the survey was designated as "Survey of Hampton Roads Shellfish Areas, 1949-1950." The area covered in the survey is shown on the maps on pages 8 and 9. A preliminary report of results obtained in the Hampton Flats section was prepared on February 23, 1950. This preliminary report is shown in Appendix III.

8.

HAMPTON ROADS SECTION
NEWPORT NEWS
NAVAL OPERATING BASE
NORFOLK
NORFOLK

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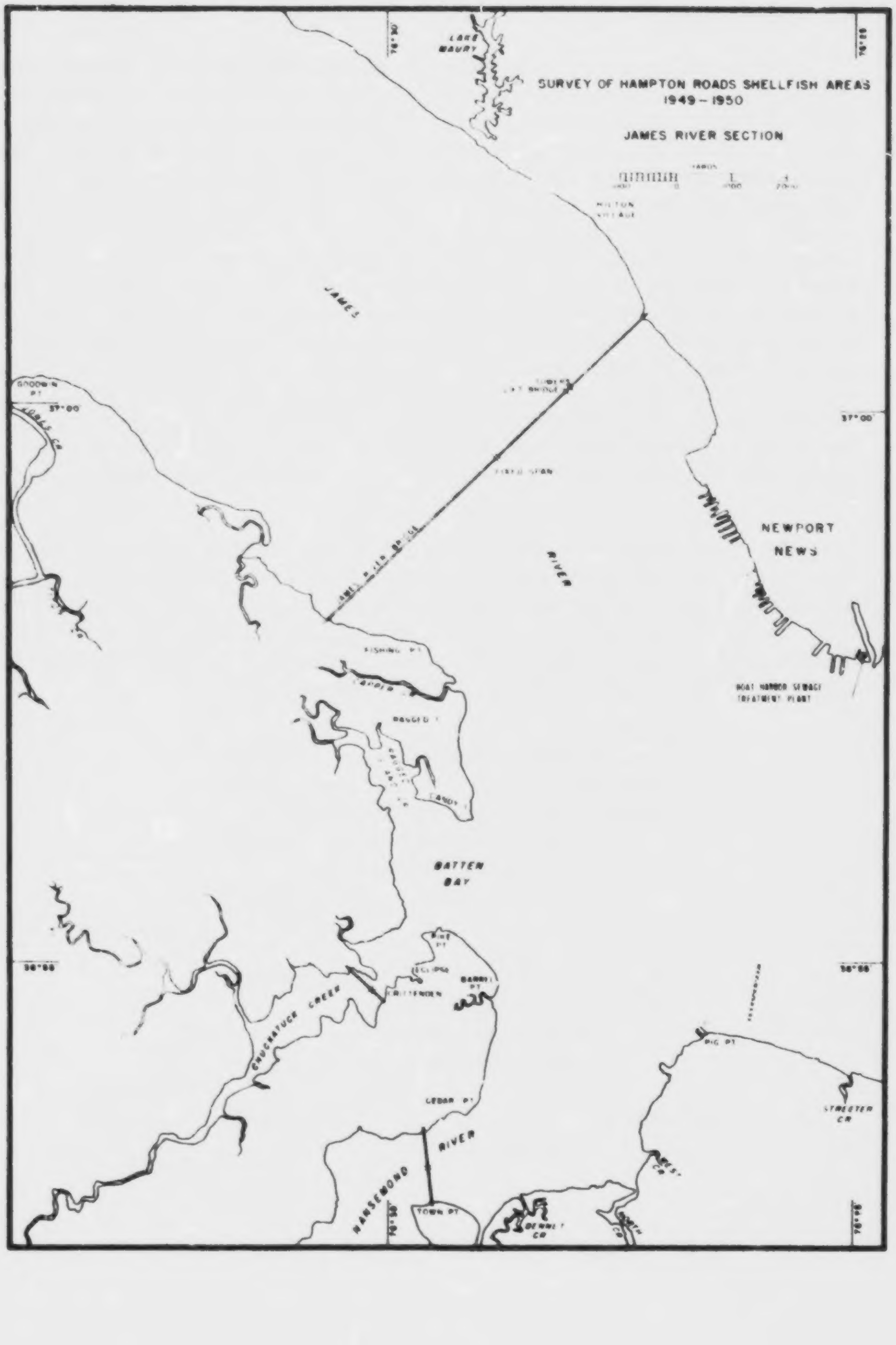

SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950

JAMES RIVER SECTION

76°30'
LAKE MAURY
76°25'
YARDS
1000
0
1000
2000
HILTON VILLAGE
JAMES
RIVER
GOODWIN PT
37°00'
37°00'
LIFT BRIDGE
FIXED SPAN
JAMES RIVER BRIDGE
NEWPORT NEWS
BOAT HARBOR SEWAGE TREATMENT PLANT
FISHING PT
RAGGED I
CANDY I
BATTEN BAY
PIKE PT
ECLIPSE
BARRELL PT
CRITTENDEN
36°55'
36°55'
CHUCKATUCK CREEK
CEDAR PT
NANSEMOND
RIVER
TOWN PT
76°30'
PIG PT
STREETER CR
DENNIS CR
CR
76°25'

IV

SANITARY SURVEYS

A. Populations

The population of the Hampton Roads area has increased greatly since the last decennial census in 1940. During the war years from 1941 to 1945, military and naval installations were greatly expanded. The ship building industries operated at peak capacity. Merchant ship movements were at a peak due to overseas shipment of men and supplies for war purposes. These war industries caused a tremendous influx of civilian population which resulted in a large amount of residential construction extending into formerly relatively unpopulated areas. Contrary to expectation, most of this increase in wartime civilian population was not lost following the cessation of hostilities. The naval operations have continued at greater than pre-war levels, and although the ship building industry has declined materially, no appreciable decline in population has occurred. The housing situation is still fairly acute. There has been a large amount of residential construction since 1945 and there has not been any marked decrease in water consumption in the area.

The 1950 census figures (recently available) indicate that the population in the area draining to the waters of Hampton Roads and the James River below the mouth of the Warwick River is 460,000. This does not include the rural populations in Isle of Wight County on the south bank of the James River northwest of the Nansemond River. This population is divided as follows:

Lower Peninsula		
Newport News (city)	41,571	
Hampton (city)	5,957	
Elizabeth City County including Phoebus (town)	54,369	
Warwick County (Newport District only)	31,058	
		132,955
Norfolk Urban Area		
Norfolk (city)	188,600	
Norfolk County (except Washington and W. Branch Dists.)	69,164	
		257,164
Portsmouth	71,294	71,294
Total		461,413

B. Sewage Treatment

There are four sewage treatment plants in the area which serve approximately 90 per cent of the sewered population. All four plants are similar in design and provide for sewage treatment by screening with grinding of the screenings and return to the sewage flow, grit chambers, primary settling, chlorination, and digestion and filtration of sludge.

The Hampton Roads Sanitation District is served by three plants, Boat Harbor, Army Base and Lambert Point. The Boat Harbor Plant has a design capacity of 12 M.G.D. and serves the entire North Shore of Hampton Roads from Hilton Village to Old Point Comfort and north on the Chesapeake Bay shoreline to include Buckroe Beach. The treated sewage is discharged to the Newport News Channel into a 23 foot depth of water 1,500 feet off Newport News Point. The Army Base Plant has a design capacity of 11 M.G.D. and serves those portions of Norfolk (including the Naval Operating Base) and Norfolk County south to the Lafayette River. The effluent is discharged to the Norfolk Harbor Channel. The Lambert Point Plant with a capacity of 22 M.G.D. serves that portion of Norfolk south of the Lafayette River, South Norfolk and that portion of Norfolk County south of the Lafayette River and east of the Elizabeth River and its Southern Branch. Effluent discharge is to shallow water (6 foot depth) in the Elizabeth River 1,500 feet north of Lambert Point.

The Pinner Point Plant of the City of Portsmouth is located a mile and a half south of Lambert Point at the junction of the Elizabeth River and Western Branch. The plant serves the entire city and the effluent is discharged to the Elizabeth River Channel 1,700 yards southeast of Lambert Point.

Two of the plants, Army Base and Pinner Point, have chlorine contact tanks. Boat Harbor and Lambert Point Plants have no contact tanks and must rely on contact time in the submerged outfall when applying chlorine to the settled sewage (post-chlorination). Prior to November 1, Lambert Point and Boat Harbor started applying all chlorine to the sewage as it entered the plant. Army Base used re-chlorination (a portion applied to the incoming sewage and a larger portion applied to the settled sewage) until December 1 at which time pre-chlorination alone was started. The Pinner Point plant used post-chlorination until January 24, when it switched to pre-chlorination. In the Sanitation District plants it was found that even with chlorine contact tanks, chlorination could be more readily controlled to ensure an effluent residual when the chlorine was applied prior to sedimentation.

Prior to December 1, the chlorination capacity at Boat Harbor Plant was inadequate and the coliform most probable number of effluent samples were in the millions. Increased chlorination capacity was installed at that time and composite samples of the effluent had a median coliform MPN of less than 30 per 100 ml. during the months of December and January.

Average daily pumpage at the various plants during the survey was as follows:

Plant	Location	M.G.D.
Boat Harbor	Newport News	8.7
Army Base	Norfolk	6.9
Lambert Point	Norfolk	13.9
Pinner Point	Portsmouth	6.1
Total		35.6

C. Raw Sewage Discharges

1. Land Population

There are still many areas discharging raw sewage, or sewage receiving septic tank treatment only, into the waters of Hampton Roads and the tributary streams. In general, the populations tributary to such individual outfall sewers are relatively small, but at certain places a population of several thousand individuals is connected to an outfall. It is estimated that at least 90 per cent of the sewage of the entire area receives treatment at the present time and negotiations are under way to connect the larger raw sewage discharges to the sewage treatment plants as soon as finances will permit. Orders have been issued to the local governmental authorities to make many of these connections and it is anticipated that most of these will be accomplished within a year.

The present status of raw sewage discharge can best be described by areas.

a. Lower Peninsula (north shore of Hampton Roads)

There are only four points on the Lower Peninsula south of the mouth of the Warwick River where sewered populations not tributary to the Boat Harbor Plant of the Hampton Roads Sanitation District discharge sewage regularly.

At the east end of the James River Bridge, located between the north limits of Newport News and Hilton Village, there are two housing developments, with a total estimated population of 4,800, discharging effluent from an inadequate septic tank into the James River. It is understood that negotiations are under way with Warwick County to connect this flow to the Sanitation District interceptor and it is hoped that this will be completed during the summer of 1950.

At Indian River, midway between Newport News Point and Old Point Comfort, there is a real estate development with a population of approximately 400 that discharges raw sewage and septic tank effluent into the west arm of Indian River.

A trunk sewer serving that area of Elizabeth City County extending north of Hampton nearly to Back River discharges raw sewage from an estimated population of 6,000 into an arm of Hampton Creek. It is anticipated that this sewer will be connected to the Hampton Roads Sanitation District system by the end of 1950.

A population of about 600 is discharging raw sewage into the upper reaches of Mill Creek (between the town of Phoebus and the Fort Monroe military reservation). Work is under way to connect these homes to a Sanitation District interceptor and it is expected that this will be completed by the summer of 1950.

b. Norfolk Area

About 35 public sewers from the Norfolk area discharge raw sewage into the Lafayette and Elizabeth Rivers. In general, these serve small areas near the waterfront with populations of 50 to 1,000 persons each and an estimated total population of 10,000. A bond issue for $100,000 was authorized by the Norfolk City Council on January 4, 1950, to construct connections for three of the larger outfalls. Plans are being drawn for connecting others in the near future.

In addition to the above public sewers, there are approximately 300 family units with direct connections to the Lafayette River and its branches. These are generally older houses on fairly large lots on isolated points and are not readily connected to existing sewers. It is estimated that the tributary population does not exceed 1,200.

Most of the industrial plants along the shoreline of the main stem of the Elizabeth River and the Eastern Branch discharge sanitary sewage directly to the tidal waters. The majority of these industries (fertilizer plants, wood creosoting plants, a cement plant, coal loading piers, and ship loading piers) are not of the type to have many employees. An automobile assembly plant and two large oyster shucking houses would probably be the largest contributors of pollution. The automobile assembly plant and a shipbuilding and drydock corporation have connected their sewers to the city system. The oyster packers are building new shucking houses to be completed during the summer of 1950 and these will be connected to city sewers. Other industries, particularly the railroads at their pier terminals, are actively engaged in diverting their sewage to the city sewer system.

c. Portsmouth Area

All sanitary sewage in the area, except that from the Naval Hospital, the Navy Yard, the St. Julian's Ammunition Depot, and an industrial area just south of the Navy Yard, is tributary to the City's Pinners Point sewage treatment plant.

The Naval Hospital has a population of 2,400. The Navy Yard has a resident population of 500 and 9,000 daytime employees or an equivalent population estimated at 3,500. The Naval Ammunition Depot has a resident population of 95 and 755 civilian daytime employees or an estimated equivalent population of 250. Thus, these naval installations discharge sewage equivalent to that of a population of 6,150. Plans have been completed and submitted with a request for appropriations for the necessary construction to discharge this sewage to the Portsmouth sewage treatment plant. Since the close of the field work on the survey, information has been received that the Secretary of Defense has released funds to connect the Navy Yard and Naval Hospital sewers to the City of Portsmouth sewer system.

The City of Portsmouth plans to connect the industries south of the Navy Yard to the city system as soon as the Navy Yard is connected and a sewer to that area is provided. The industries concerned consist of a creosoting plant, two mahogany veneer plants, a soy bean processing plant, and a vegetable shortening plant. Probably only the latter two have a sanitary sewage load of consequence.

2. Floating Population

Hampton Roads is essentially a port area for both merchant ships and naval vessels. Thus, a considerable floating population discharges raw sewage into the waters of the area whether the ships are at anchor or tied up to wharves, no provision being made on ocean-going ships to discharge sewage to city sewers when they are at the dock.

The merchant ships do not present as great a problem as the naval vessels. The crews are smaller and the ships are dispersed over wider areas in the harbors. The majority of the merchant ships dock at piers along the Norfolk Harbor-Elizabeth River channel and its branches, although there is a lesser amount of docking along the Newport News waterfront. Some vessels anchor in the Roads for varyihg periods, although this is not a common practice when port facilities are no more crowded than they were during the period of this survey.

A study of reported port movements indicates that an average of eight merchant vessels arrived daily and averaged three days each in port. It is estimated on the basis of newspaper items that the crews would average 50 men per ship. This would indicate a floating merchant marine population of approximately 1,200 of which it is estimated that possibly 800 would be in the Norfolk-Portsmouth area.

It is much more difficult to obtain an estimate of the naval floating population. The number of naval vessels in port varies greatly and is dependent on maneuvers under way or planned. Most of the naval vessels in port are berthed at piers at the Naval Operating Base at the north end of the Norfolk Harbor Channel, with a smaller number at piers at the Navy Yard, the Ammunition Depot, and at other minor installations. On some occasions ships are anchored in the Roads when the piers are all occupied. Observation would lead to the belief that the personnel actually on board the ships normally in port would be from 5,000 to 8,000, mostly concentrated at piers at the Naval Operating Base.

3. Intermittent Discharge

a. Lower Peninsula Area

The old outfalls from the various sewer systems are still extant and serve as emergency overflows from the several pumping stations of the Sanitation District. Because the sewers are for sanitary sewage only and the pumping stations are said to have a capacity of three or four times the present dry weather flow, these emergency outfalls do not ordinarily come into operation except at times of electrical or mechanical failure. The pumping stations are visited daily by a crew from the Boat Harbor Plant for maintenance purposes. During the approximate period of this survey there were but two recorded occasions that these overflows came into action. On October 1 approximately 500 gallons of sewage overflowed into Hampton Creek at Bridge Street pumping station due to an air lock in a pump caused by worn packing. On December 5 an estimated 500,000 gallons overflowed to Hampton Flats from the Claremont Pumping Station approximately 1,000 yards east of Indian River. This overflow was caused by clogging of a float tube on the pump control. In addition to these discharges, raw sewage was discharged to Salter Creek for about three weeks in January while the City of Newport News was extending an inverted siphon across the site of a proposed yacht basin to its Salter Creek pumping station.

b. Norfolk Area

Emergency overflows from city and Sanitation District pumping stations exist at many points along the Lafayette River and the Elizabeth River. During the period of the survey the records of the Sanitation District Commission indicated four occasions when such an overflow was in operation. On both October 7 and November 7, Pumping Station 23 allowed approximately 3,000 gallons to discharge to the Lafayette River at City Park. On October 31 about 700,000 gallons were discharged to the Eastern Branch of the Elizabeth River at the foot of Norchester Avenue, due to a mechanical failure on the main pump at Station 24. Failure of an automatic cone valve caused the discharge of 50,000 gallons at the same station on December 5.

There are three storm water overflows from control chambers on combined sewers in the Naval Operating Base. These control chambers are supposed to pass 200 per cent of the normal dry weather flow to the interceptor before discharging over a weir wall to the overflow. It was stated that there are tide gates on the old outfalls and that a high tide would hold the gates closed and at such times the flow would have to exceed twice the dry weather average to discharge to salt water. The Naval Operating Base interceptor flows to a pumping station with four pumps having a total rated capacity of 13.7 MGD. The gravity discharge line leading from this pumping station to Army Base Plant is stated to have a capacity of 11 MGD. No record is available to show when these storm water overflows have operated, but there is no doubt that they would come into operation at times of heavy storms.

During the period of the survey there were only five days that had a 24-hour rainfall in excess of 0.50 inch and only one day with rainfall in excess of 1.00 inch.

In addition to the above overflows of sewage, records of the Sanitation District Commission show that there were four occasions that plant operation was interrupted by power failure. The Lambert Point Plant was out of operation twice on November 24 with a resultant by-passing of 1.8 million gallons and again on December 4 with 0.5 million gallons by-passed. The Army Base plant was out of operation on November 24 with 0.15 million gallons by-passed. On November 1, due to a heavy runoff incident to a rainfall of 3.20 inches in 24 hours, the Army Base Plant was hydraulically overloaded and an estimated one million gallons was by-passed, although the plant was treating three times the normal flow.

On December 9 a leak was discovered in the sewage force main under the Eastern Branch of the Elizabeth River. Investigation disclosed that a large section of the lead caulking had blown out of a bell near the southern bank in a water depth of 20 feet. It became necessary to divert the flow from that part of the system south of the Eastern Branch into the Elizabeth River until repair work could be completed, which was accomplished on December 16.

c. Portsmouth Area

There are no emergency overflows from the Portsmouth sewer system, except the by-pass line at the sewage treatment plant. The system is for sanitary sewage only and the sewage flows by gravity through local sewers to suction wells, thence through lines under a negative head to the principal pumping stations and thence through force mains to the treatment plant. The only connections to the Elizabeth River are valved flushing (intake) connections which may be operated manually.

During the period of this survey the only record of by-passing at the Portsmouth plant was on November 27, 28 and 29, when the entire flow, or a total of approximately 18 million gallons, was by-passed because of violent foaming in the digestors.

V

TIDAL CURRENTS

Hampton Roads is affected by strong and variable tidal currents which are greatly influenced by the existing channels and shorelines, and also by wind direction. Due to these influences, flood and ebb currents at any given spot do not correlate with the time of predicted high and low tide.

In the south channel to Newport News (south of Newport News Middle Ground) the ebb continues to run about 1 hour 15 minutes after low water, while in the north channel it runs about 20 minutes after low water. Normal currents in the main channel near Old Point Comfort Light vary from 1.4 to 2 miles per hour, those in the center of the Roads between Middle Ground and Sewell Point vary from 1 to 1.4 miles per hour and those off the Newport News Shipyard from 1.3 to 1.7 miles per hour. There is a much lower velocity on the flats and conditions vary greatly in different parts of the Roads; for instance, the tides turn in the Hampton Creek channel inside Hampton Bar about 30 minutes before they turn in the main channel only a few hundred feet distant. Near the dock at Old Point Comfort the current turns from 45 minutes to one hour earlier than in mid-channel about 700 yards to the southward. It follows that during the period of about an hour which elapses between each slack water at the dock and the corresponding slack water in midstream, the currents at the two locations are flowing in opposite directions. The boundary between these two streams is generally visible as a line of tide rips, which is said to have a normal position (changing with meteorological conditions, however) about 100 yards off the dock.

During ebb tide there is everywhere a convergence of waters from the tributaries and flats to the greater velocity of the main channel. The great volume of water from the James River, sweeping around a curve, follows the main channel of the Roads, and sedimentation takes place where the currents from the Nansemond and Elizabeth Rivers somewhat oppose and retard the flow, thus forming Nansemond Ridge and Craney Island Flats. The water from the Elizabeth River is constantly forced against the east bank by the ebb tide from the James and Nansemond Rivers. Thus the polluted waters from the Lafayette and Elizabeth Rivers follow a straight narrow channel north past the Naval Operating Base and out to Chesapeake Bay through the main channel and, in part, across the flats of

Sewell Point Spit and Willoughby Bank without any appreciable diffusion to the west over Craney Island Flats.

On the flood tide, Sewell Point Spit and that area of Norfolk north of Lafayette River apparently prevent much lateral pushing westward over Craney Island Flats of the last ebb tide waters from the Elizabeth River; and the current, running almost directly southward, tends to return these waters into the river and its various tributaries. The wide, funnel-shaped mouths of the James and Nansemond Rivers receive almost all of the upward thrust of the flood tide.

VI

SAMPLING

A. Location of Sample Points

In order to obtain representative data showing the bacterial quality of the water over the various shellfish areas of Hampton Roads and vicinity, numerous samples were taken from over 150 sample points located to provide adequate coverage of the areas under consideration.

In the spring of 1948 the State Department of Health adopted a coordinate grid system for sample point nomenclature in the Hampton Roads area. This system was intended to eliminate the confusion arising from the arbitrary numbering of sample points, which had been used on previous surveys, and the consequent repetition of the same number for differing points. This grid consists of rectangles laid out with sides 20 seconds in longitude and 15 seconds in latitude or approximately 540 yards by 510 yards. These rectangles are in the third quadrant with the origin at 37 degrees, 3 minutes, 30 seconds north latitude and 75 degrees, 10 minutes, 20 seconds west longitude. The X coordinate is numbered in the negative direction from 1 to 74. The Y coordinate is lettered in the negative direction from A to ZZ.

This coordinate grid was laid out on U. S. Coast and Geodetic Survey charts of this area (United States - East Coast - Virginia - Hampton Roads - No. 400-1944 Edition - Corrected to September,1949; and United States - East Coast - Chesapeake Bay, Virginia - James River, Newport News to Jamestown Island - No. 529 - 1944 Edition - Corrected to September 1949). Sample points were then spotted on the charts to cover adequately the areas under study, using points from surveys made in the period 1945 to 1949 wherever possible. In general, these points were 500 to 1,000 yards apart, although on the west side of the James River they were more scattered. All sample points were designated by the coordinate rectangle in which they appeared. The location and number of each sample point (except 4 on the Elizabeth River south of Lambert Point) are shown on Figures 1 and 2.

Several trips were made to each area by boat to locate the various sample points and to describe them by cross ranges to navigation markers and recognizable objects on shore or by sailing courses and compass bearings to shore objects. "Sample Course Directions" were prepared for each sampling run, giving the boat courses to be followed and a detailed description of each point. One of these "Sample Course Directions" and a descriptive listing of all sample points are given in Appendix I.

Willoughby Bay is a restricted area, used by the Navy for seaplane landings, where anchoring, trawling, fishing and dragging are prohibited and therefore it was not sampled. Mill Creek is a wide, but very shallow, tidal pond, polluted at the upper end by raw sewage and with two low clearance, fixed bridges at the outlet end which will pass only small power boats. The only samples taken in this estuary were at the bridges at the mouth of the creek.

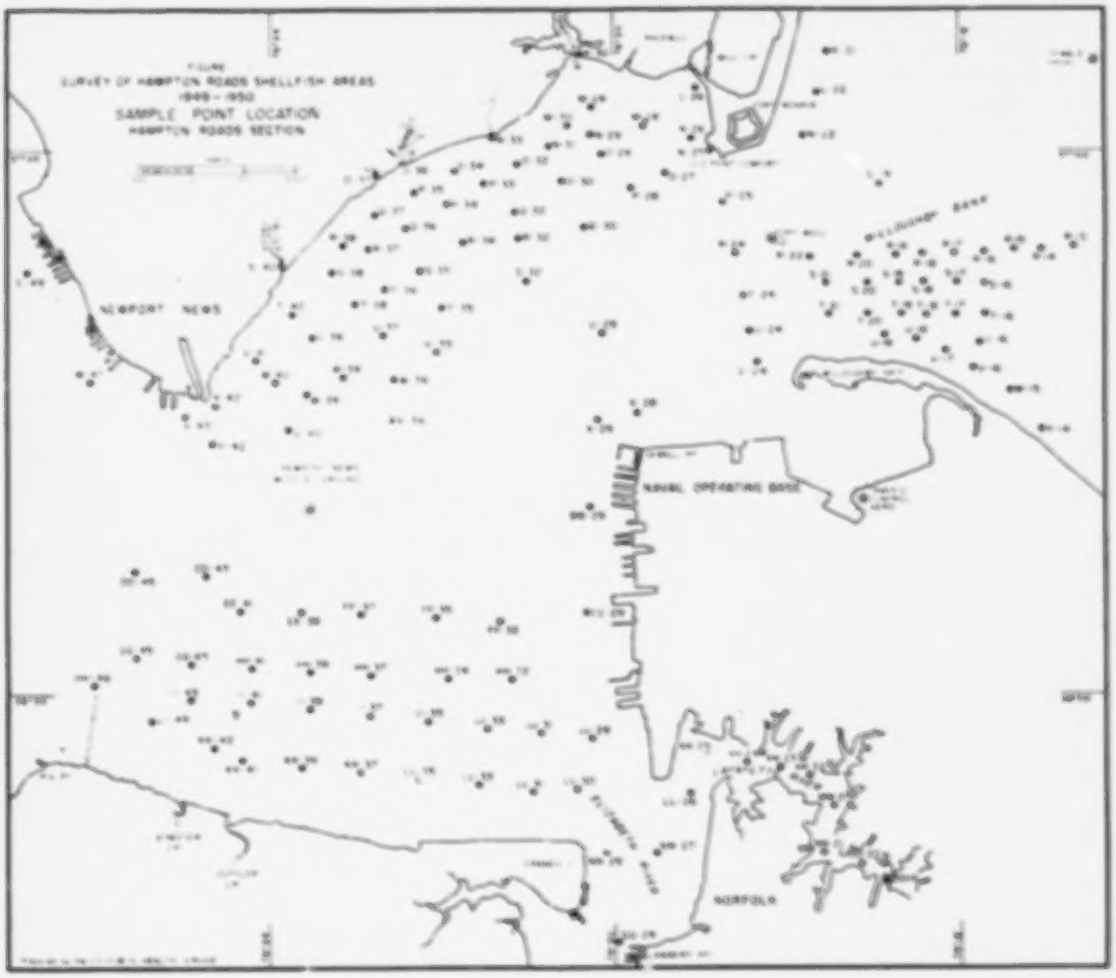
FIGURE
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 - 1950
SAMPLE POINT LOCATION
HAMPTON ROADS SECTION
NEWPORT NEWS
WILLOUGHBY BANK
NAVAL OPERATING BASE
ELIZABETH RIVER
NORFOLK

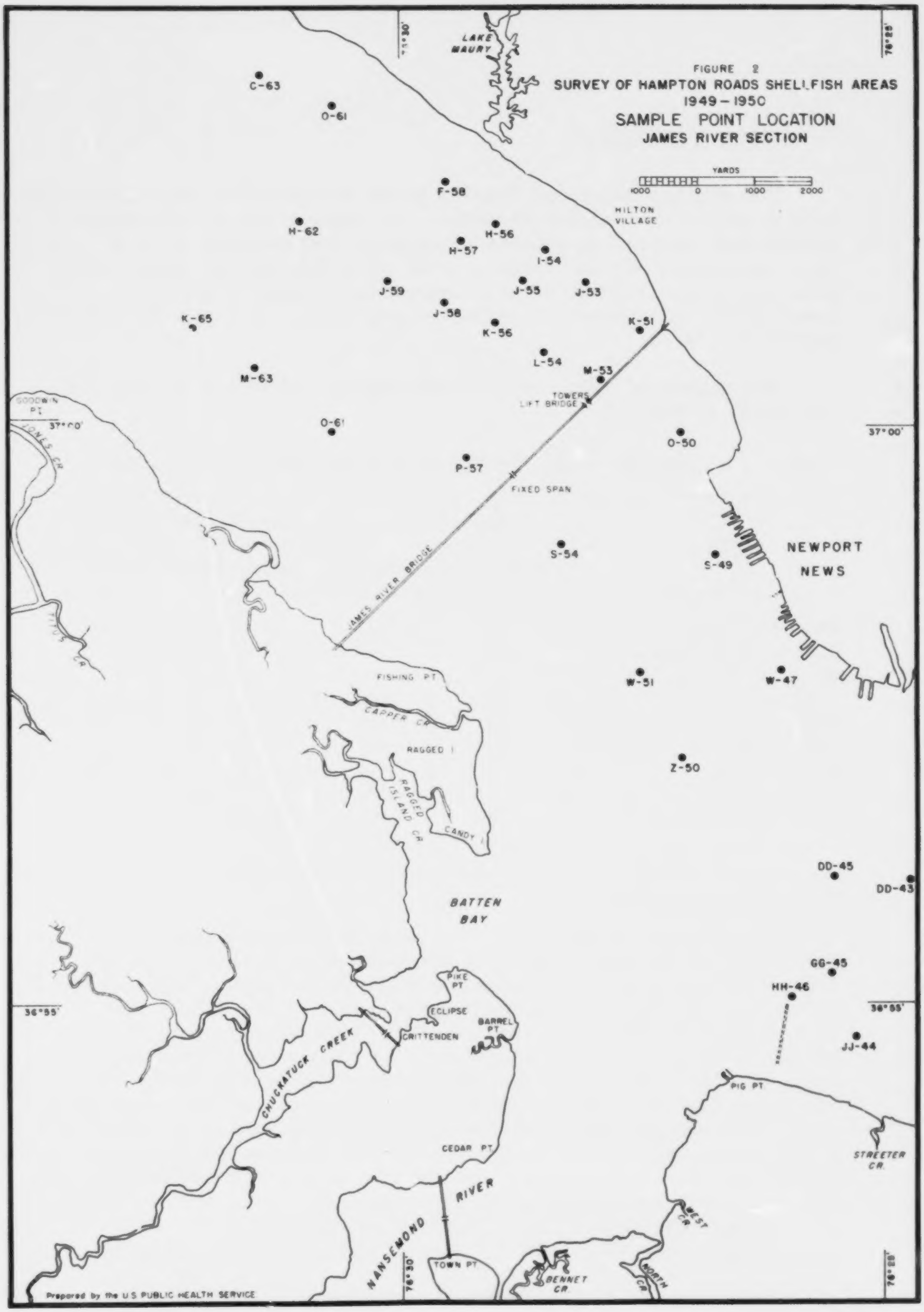

FIGURE 2

SURVEY OF HAMPTON ROADS SHELLFISH AREAS

1949 – 1950

SAMPLE POINT LOCATION

JAMES RIVER SECTION

YARDS
1000
0
1000
2000
LAKE MAURY
HILTON VILLAGE
C-63
O-61
F-58
H-62
H-56
H-57
I-54
J-59
J-55
J-53
J-58
K-65
K-56
K-51
L-54
M-63
M-53
TOWERS
LIFT BRIDGE
GOODWIN PT
37°00'
JONES CR
O-61
O-50
P-57
FIXED SPAN
S-54
S-49
NEWPORT NEWS
JAMES RIVER BRIDGE
TYUS CR
W-51
W-47
FISHING PT
CAPPER CR
RAGGED I
RAGGED ISLAND CR
CANDY I
Z-50
DD-45
DD-43
BATTEN BAY
GG-45
HH-46
JJ-44
36°55'
PIKE PT
ECLIPSE
BARREL PT
CRITTENDEN
CHUCKATUCK CREEK
PIG PT
STREETER CR.
CEDAR PT
NANSEMOND RIVER
WEST CR
TOWN PT
BENNET CR.
NORTH CR
76°30'
76°25'
Prepared by the U.S. PUBLIC HEALTH SERVICE

B. Sample Distribution

The shallow waters of Hampton Roads and vicinity were subdivided into 9 areas for sampling purposes. In these 9 areas, 169 sample points were located to provide representative coverage of each area. Over the period of the survey a total of 2,656 routine water samples were collected at these points, averaging 16 samples per point. The least number of samples collected at any point was 5 and the greatest number was 40.

The number of sample points and samples collected in each area are shown in Table 1.

TABLE 1 - SAMPLING AREAS, SAMPLE POINTS AND SAMPLES COLLECTED

Area	Number of		Samples per Point		
	Sample Pts.	Samples	Max.	Min.	Aver.
Hampton Flats	45	970	40	5	22
North Shore Inlets	6	57	10	8	9
Norfolk Harbor Channel-Elizabeth River	12	146	19	6	12
Lafayette River	10	100	12	9	10
Craney Island Flats	30	390	18	7	13
Fort Monroe	6	34	6	5	6
Mouth of Roads	6	201	34	33	34
Willoughby Bank	28	392	18	6	14
James River	26	366	22	5	14

C. Sampling Methods

Samples were taken in sterile, wide mouth, glass stoppered bottles of 60 ml. capacity. The stopper was protected by an aluminum foil cover pressed around the neck of the bottle before sterilization. As the boat approached the sample point the stopper with protecting foil cover was carefully removed, the neck of the bottle inserted in a spring wire clip at the end of a four foot pole, and the sample was taken by quickly dipping the bottle below the water surface with a sweeping motion against the motion of the boat. The stopper and protective foil were replaced in a manner to avoid contamination, the bottle was marked with the sample point number and placed in an iced container to maintain a temperature of 4 to 5 degrees centigrade until it reached the laboratory. All samples were brought to the laboratory and planted within four hours after collecting. At the time of collection all essential field data were noted on an individual sample card 5 inches x 8 inches in size. These data included the number of the sample bottle used (the bottles were numbered serially), the sample point designation, the water area being sampled (i.e., Craney Island Flats, James River, etc.), the date, weather conditions, time collected, tide cycle at collection point and the sample collector's initials. Space was provided for entry of wind data, but as the sample boats were not equipped with weathervane or anomometer, it was found more satisfactory to take this information from weather bureau reports. Data on water temperature, salinity and air temperature were taken at three sample points on each sampling trip and entered on the sample cards for those points. The sample cards were delivered to the laboratory with the samples and there served as individual bench cards for the entry of laboratory data. Thus all information for any one sample was entered on a single card. This sample card is illustrated in Appendix II.

VII

LABORATORY METHODS

When the samples were received at the laboratory, the bottles were checked against the accompanying sample cards and each sample given a laboratory serial number. The samples were then planted for the determination of coliform most probable number in accordance with the procedure in "Standard Methods for the Examination of Water and Sewage, 9th Edition, 1946," using 3 tubes in each of three or four decimal dilutions and confirming positive tubes by inoculation into brilliant green bile lactose broth. The laboratory data for each sample were entered on the corresponding sample-laboratory card (See Appendix II), the most probable number was determined and entered, and all pertinent information was entered on the summary sheet for the particular sample point. This summary sheet (illustrated in Appendix II) became the permanent record for all samples taken at that point.

The individual sample-laboratory cards were filed chronologically under the sample point designation. They were later used, by rearranging in various groupings and in order of MPN magnitude, to make possible the rapid, accurate determination of maximum, minimum and median MPN values.

The original sample-laboratory cards and the complete set of summary sheets have been filed in the office of the Division of Engineering, Department of Health, Commonwealth of Virginia, in Richmond.

VIII

SUMMARY OF BACTERIOLOGICAL DATA

The bacteriological data obtained during this survey of Hampton Roads waters have been summarized in Tables 2 and 3.

Table 2 shows the maximum, minimum and median coliform MPN per 100 ml. for each sample point in three chronological periods: first, for the entire survey; second, for October and November; and third, for December to February inclusive. It has been noted in Section IV, that prior to December 1 the chlorinator capacity at Boat Harbor Sewage Treatment Plant in Newport News was insufficient to provide adequate chlorination for the heavy flow period during the afternoon. An additional chlorinator was installed in this plant on December 1 and a much closer control of chlorination was initiated. About the same time, more careful control of chlorination was established at the other plants of the Sanitation District. By December 1, the City of Portsmouth plant at Pinners Point apparently had succeeded in overcoming many of its initial operational problems and was believed to be turning out a more satisfactory effluent. It seemed likely, therefore, that there might be a significant improvement in bacterial quality of the waters subsequent to December 1. Table 2 shows that such an improved water quality was evident over much of the area. It is significent that no such improvement was noted in the Lafayette River which would be less directly affected by quality of the plant effluents.

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						HAMPTON FLATS						
K-30	22	5	17	15000	9.1	240	15000	75	+1100	2400	9.1	240
L-26	10	-	10	93	15	43	-	-	-	93	15	43
M-28	25	8	17	240	3.6	43	240	3.6	43	93	3.6	23
M-29	24	7	17	460	9.1	43	460	9.1	23	150	9.1	43
M-30	22	8	14	240	3.6	43	93	3.6	43	240	9.1	33
N-26	23	6	17	460	3.6	23	93	9.1	23	460	3.6	43
N-29	22	8	14	460	3.6	33	460	3.6	43	93	9.1	23
N-31	20	6	14	460	3.6	43	240	14	93	460	3.6	33
O-27	12	6	6	93	3.6	23	93	3.6	33	43	9.1	12
O-29	21	7	14	150	3.6	23	150	9.1	43	93	3.6	23
O-30	21	7	14	460	3.6	23	460	9.1	23	43	3.6	19
O-32	18	4	14	460	3.0	23	460	20	132	150	3.0	23
O-34	25	8	17	+1100	3.6	43	+1100	3.6	43	460	9.1	43
P-28	12	6	6	93	7.3	23	93	7.3	33	93	9.1	23
P-33	22	8	14	240	-3.0	23	240	3.0	43	150	-3.0	23
P-34	24	7	17	1100	-3.0	23	1100	9.1	23	93	-3.0	23
P-35	27	8	19	460	3.6	43	460	3.6	68	460	3.6	43
Q-30	13	6	7	93	9.1	23	93	23	43	43	9.1	9.1
Q-32	22	8	14	240	9.1	23	240	9.1	33	240	9.1	23
Q-36	26	8	18	1100	-3.0	23	1100	3.6	33	43	-3.0	19
Q-37	27	8	19	+1100	3.6	23	460	3.6	33	+1100	3.6	23
R-32	5	1	4	43	3.6	21	21	21	21	43	3.6	16
R-34	23	8	15	240	7.3	23	240	7.3	43	93	15	23
R-37	27	9	18	1100	-3.0	23	1100	-3.0	23	150	-3.0	23
R-38	28	9	19	+1100	3.6	43	+1100	3.6	43	1100	9.1	43

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						HAMPTON FLATS (Contd.)						
S-32	15	6	9	93	3.0	23	93	23	23	93	3.0	23
S-35	26	8	18	1100	3.6	23	1100	9.1	122	43	3.6	23
S-38	29	9	20	460	3.6	23	460	3.6	23	160	3.6	23
T-35	15	7	8	1100	9.1	23	1100	23	43	75	9.1	23
T-30	28	9	19	1100	3.6	23	1100	23	43	460	3.6	23
T-38	27	9	18	+1100	3.6	23	+1100	7.3	43	240	3.6	23
T-40	28	8	20	+1100	3.6	43	+1100	3.6	68	240	3.6	33
U-37	15	6	9	1100	3.6	43	1100	43	93	93	3.6	23
U-39	28	9	19	4600	-3.0	43	4600	21	43	240	-3.0	43
V-35	17	6	11	93	3.6	23	93	9.1	31	75	3.6	23
V-41	28	8	20	1100	11	93	1100	43	605	1100	11	75
W-36	17	6	11	+1100	9.1	23	+1100	14	68	43	9.1	23
W-38	14	4	10	460	9.1	43	460	23	97	460	9.1	43
W-39	18	7	11	1500	7.3	43	1500	23	460	93	7.3	23
W-40	24	6	18	+1100	9.1	23	+1100	9.1	43	93	9.1	23
X-36	19	5	14	460	9.1	23	460	9.1	93	150	15	23
X-42	40	12	28	4600	9.1	43	4600	23	335	240	9.1	41
X-43	22	8	14	+1100	7.3	68	1500	23	137	+1100	7.3	68
Y-40	20	5	15	+1100	9.1	43	+1100	43	93	240	9.1	23
Y-42	19	9	10	1100	9.1	43	1100	23	43	93	9.1	23
						NORTH SHORE INLETS (EBB TIDE)						
K-25	10	-	10	930	23	93	-	-	-	930	23	93
K-26	10	-	10	+1100	7.3	23	-	-	-	+1100	7.3	23
N-33	10	-	10	+11000	150	1520	-	-	-	+11000	150	1520
O-36	10	-	10	460000	1400	+11000	-	-	-	460000	1400	+11000
O-37	8	-	8	+11000	360	1660	-	-	-	+11000	360	1660
S-40	9	-	9	+110000	91	930	-	-	-	+110000	91	930

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						BOAT HARBOR TREATMENT PLANT EFFLUENT						
	132	29	103	110 mil.	-30	55	110 mil.	-300	4300000	+1100000	-30	-30
						NORFOLK HARBOR CHANNEL - ELIZABETH RIVER						
U-29	15	7	8	1100	23	43	1100	23	93	460	23	43
X-28	9	-	9	460	43	150	-	-	-	460	43	150
X-29	9	-	9	1100	43	93	-	-	-	1100	43	93
BB-29	16	5	11	1100	23	240	430	93	240	1100	23	150
EE-29	17	5	12	1100	23	93	930	93	240	1100	23	68
JJ-29	17	5	12	+1100	23	240	930	23	240	+1100	39	235
NK-29	19	6	13	24000	-30	230	24000	43	2415	+1100	-30	93
QQ-28	19	6	13	46000	36	460	46000	430	3500	2300	36	460
TT-28	6	-	6	+11000	91	1620	-	-	-	+11000	91	1620
TT-28A	6	-	6	4300	-30	430	-	-	-	4300	-30	430
UU-27	6	-	6	+11000	230	2370	-	-	-	+11000	230	2370
VV-26	6	-	6	+11000	150	965	-	-	-	+11000	150	965
						LAFAYETTE RIVER						
KK-22	9	4	5	+11000	230	930	4300	230	680	+11000	460	930
KK-23	9	4	5	11000	150	430	2300	150	330	11000	230	460
KK-24	11	4	7	2400	230	930	2300	430	1515	2400	230	460
KK-25	11	4	7	4300	93	460	4300	93	570	2400	93	460
LL-26	12	5	7	1500	93	445	1500	93	430	+1100	150	460
MM-21	9	4	5	2400	150	430	2300	150	330	2400	240	750
NN-21	9	4	5	4300	230	930	4300	230	680	2400	460	930
NN-27	12	5	7	4600	43	460	1100	43	93	4600	150	460
OO-19	9	4	5	110000	430	1500	110000	430	965	2400	430	2300
OO-20	9	4	5	7500	43	930	7500	43	930	2400	210	430

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						CRANEY ISLAND FLATS						
DD-43	11	5	6	240	3.6	23	43	15	43	240	3.6	19
EE-39	14	5	9	240	3.6	43	240	23	93	93	3.6	23
EE-41	11	5	6	43	3.6	23	43	23	23	43	3.6	23
FF-32	13	5	8	240	3.6	43	240	43	75	75	3.6	33
FF-35	14	5	9	93	3.6	23	93	23	43	43	3.6	15
FF-37	13	5	8	150	3.6	43	150	39	43	43	3.6	23
GG-43	8	6	2	150	3.6	41	150	3.6	43	39	9.1	24
GG-45	8	6	2	240	3.6	23	240	3.6	23	23	3.6	13
HH-32	15	5	10	430	9.1	43	430	23	33	93	9.1	41
HH-34	15	5	10	93	-3.0	23	75	9.1	43	93	-3.0	23
HH-37	13	5	8	240	3.6	23	93	9.1	43	240	3.6	23
HH-39	13	5	8	93	9.1	23	93	23	43	93	9.1	23
HH-41	7	5	2	93	-3.0	23	93	9.1	23	43	-3.0	22
HH-46	9	5	4	93	3.6	15	93	15	43	9.1	3.6	8.2
II-35	16	6	10	120	-3.0	23	93	3.6	43	120	-3.0	16
II-37	16	6	10	75	-3.0	23	75	23	31	43	-3.0	22
II-39	16	6	10	93	-3.0	23	93	9.1	33	43	-3.0	19
II-41	9	6	3	93	3.6	9.1	93	3.6	23	9.1	9.1	9.1
II-43	8	5	3	240	9.1	23	240	9.1	43	23	9.1	14
JJ-31	17	6	11	>1100	9.1	93	>1100	43	167	1100	9.1	43
JJ-33	17	6	11	460	-3.0	39	460	23	43	93	-3.0	23
JJ-44	9	5	4	150	3.6	23	150	23	93	23	3.6	3.6
KK-37	16	5	11	93	9.1	23	93	23	23	93	9.1	15
KK-39	16	5	11	120	-3.0	9.1	75	9.1	43	120	-3.0	9.1
KK-41	9	5	4	93	-3.0	9.1	93	3.6	43	9.1	-3.0	9.1

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
CRANEY ISLAND FLATS (Contd.)												
KK-42	9	5	4	75	3.6	9.1	75	3.6	23	9.1	7.3	9.1
LL-30	18	6	12	/11000	23	150	/11000	43	590	1100	23	122
LL-31	17	5	12	/1100	3.6	23	/1100	23	93	93	3.6	23
LL-33	17	5	12	240	3.6	23	240	23	43	43	3.6	23
LL-35	16	5	11	93	3.6	23	93	23	43	43	3.6	23
FORT MONROE												
O-20	6	3	3	23	3.6	9.1	23	9.1	23	9.1	3.6	9.1
I-21	5	2	3	23	-3.0	9.1	15	9.1	12	23	-3.0	3.6
K-21	6	3	3	93	3.6	16	93	9.1	23	23	3.6	9.1
L-22	6	3	3	240	7.3	16	240	9.1	23	23	7.3	9.1
N-22	6	3	3	93	9.1	19	93	9.1	43	23	9.1	15
O-19	5	3	2	240	23	75	240	23	240	75	23	49
MOUTH OF ROADS												
N-25	34	18	16	430	9.1	43	430	23	93	93	9.1	23
P-25	34	18	16	460	7.3	43	460	43	93	240	7.3	43
R-24	34	18	16	1100	3.6	93	1100	23	93	460	3.6	43
T-24	33	18	15	1100	3.6	43	1100	23	167	1100	3.6	43
U-24	33	18	15	460	7.3	93	460	43	195	460	7.3	43
V-24	33	18	15	1100	9.1	240	1100	23	240	460	9.1	93
WILLOUGHBY BANK												
R-13	11	6	5	93	3.6	23	93	7.3	23	93	3.6	23
R-14	10	5	5	93	3.6	29	93	3.6	43	75	3.6	15
R-15	10	5	5	43	-3.0	31	43	23	43	43	-3.0	23
R-16	12	3	9	150	3.6	16	150	9.1	43	93	3.6	9.1
R-17	13	4	9	240	3.6	23	240	9.1	68	93	3.6	23

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						WILLOUGHBY BANK (Contd.)						
R-18	15	5	10	1100	9.1	43	1100	43	43	93	9.1	33
R-19	15	5	10	240	3.6	23	240	21	39	43	3.6	23
R-20	15	5	10	460	3.6	23	460	9.1	43	240	3.6	23
R-22	15	5	10	/1100	3.6	43	240	23	93	/1100	3.6	33
S-16	16	5	11	460	3.0	33	460	3.0	43	240	9.1	23
S-17	16	5	11	1100	3.6	43	1100	23	93	93	3.6	23
S-18	14	3	11	1100	-3.0	43	1100	23	43	460	-3.0	43
S-19	15	4	11	460	3.6	43	240	23	142	460	3.6	43
S-20	15	4	11	460	3.6	43	460	9.1	68	240	3.6	23
S-21	16	5	11	1100	-3.0	93	1100	43	460	460	-3.0	43
T-16	16	4	12	240	3.6	19	93	9.1	12	240	3.6	31
T-17	17	5	12	240	-3.0	43	93	23	43	240	-3.0	33
T-18	15	3	12	240	3.0	43	43	9.1	23	240	3.0	43
T-19	17	5	12	240	-3.0	43	93	-3.0	43	240	3.6	33
T-20	17	5	12	1100	-3.0	43	1100	9.1	240	210	-3.0	43
T-21	18	6	12	1100	3.6	68	1100	9.1	152	1100	3.6	43
U-16	15	4	11	460	-3.0	9.1	93	7.3	43	460	-3.0	9.1
U-18	15	4	11	240	-3.0	23	240	23	142	93	-3.0	23
U-19	15	4	11	460	-3.0	23	460	15	68	460	-3.0	23
V-16	13	2	11	240	-3.0	43	240	240	240	93	-3.0	23
V-17	14	3	11	460	-3.0	43	460	43	460	240	-3.0	23
W-15	6	-	6	23	3.6	13	-	-	-	23	3.6	13
Y-14	6	-	6	39	3.6	23	-	-	-	39	3.6	23

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						JAMES RIVER						
C-63	10	5	5	93	-3.0	9.1	93	-3.0	9.1	43	-3.0	9.1
D-61	9	4	5	93	3.6	23	93	15	23	43	3.6	15
F-58	13	7	6	1100	3.6	23	240	23	43	1100	3.6	19
H-56	18	5	13	1100	9.1	43	93	23	43	1100	9.1	43
H-57	18	5	13	1100	3.6	23	1100	9.1	23	75	3.6	23
H-62	11	5	6	43	3.6	23	43	9.1	23	43	3.6	23
I-54	20	7	13	460	3.6	43	460	23	93	460	3.6	43
J-53	9	-	9	>1100	3.6	43	-	-	-	>1100	3.6	43
J-55	8	-	8	460	3.6	33	-	-	-	460	3.6	33
J-58	19	5	14	1100	3.6	23	1100	9.1	43	93	3.6	23
J-59	21	7	14	460	3.6	23	460	9.1	93	75	3.6	23
K-51	18	5	13	>1100	3.6	122	>1100	93	460	>1100	3.6	75
K-56	21	7	14	>1100	-3.0	43	>1100	3.6	150	240	-3.0	23
K-65	5	1	4	43	3.6	7.3	43	43	43	15	3.6	6
L-54	19	5	14	460	3.6	23	460	21	93	93	3.6	23
M-53	21	7	14	>1100	9.1	43	>1100	9.1	93	93	43	21
M-63	5	1	4	23	3.6	23	23	23	23	23	3.6	14
O-50	20	7	13	1100	23	93	1100	64	240	460	23	93
O-61	7	-	7	43	9.1	23	-	-	-	43	9.1	23
P-57	10	4	6	240	3.6	15	240	9.1	68	23	3.6	12
S-49	21	7	14	1100	9.1	43	1100	23	93	1100	9.1	43
S-54	10	4	6	150	9.1	23	150	9.1	68	43	9.1	16
W-47	22	8	14	240	23	75	240	43	75	240	23	68
W-51	10	4	6	93	3.6	23	93	23	33	43	3.6	16

TABLE 2 - SUMMARY OF BACTERIOLOGICAL RESULTS BY CHRONOLOGICAL PERIODS

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October-November			December-February		
	Total	Oct.-Nov.	Dec.-Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						JAMES RIVER (Contd.)						
Z-50	10	4	6	93	3.6	23	43	23	33	93	3.6	13
DD-45	11	4	7	150	9.1	23	93	23	33	150	9.1	23

≠ indicates indeterminate but greater than value shown.

- indicates indeterminate but less than value shown.

Table 3 shows the maximum, minimum and median coliform MPN per 100 ml for each sample point for ebb and flood tide conditions and for all samples. The distribution of samples between flood and ebb tide cycles was based upon observed direction of tidal currents at the particular sample point at the time of sampling. Due to the extremely variable currents of the area it was not considered advisable to determine tide cycle by relation of the time the sample was collected to the time of predicted high and low water.

On Hampton Flats there were no great differences in the median water qualities between flood and ebb tides. For most of this area, however, it is to be noted that ebb tide maxima are generally significantly higher than those for flood tide, indicating the sweep of pollution from the Boat Harbor sewage treatment plant and some of the north shore inlets across the flats on the ebb tide and the return of less polluted water from Chesapeake Bay and the main channel on the flood tide. On Craney Island Flats there is a slight increase in most probable numbers on ebb tide, but, except along the Norfolk Harbor channel, the water quality is good throughout the tidal cycle.

In the Elizabeth River the ebb tide results (both maxima and medians) are much higher than those for flood tide. This condition does not hold for the Norfolk Harbor Channel to the north. The results obtained in the James River clearly indicate the effects of the tidal cycle on the spread of sewage pollution discharged at the east end of the James River Bridge.

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						HAMPTON FLATS						
K-30	22	8	14	15000	9.1	240	2400	9.1	240	15000	23	375
L-26	10	3	7	93	15	43	43	23	39	93	15	43
M-28	25	9	16	240	3.6	43	93	3.6	43	240	3.6	33
M-29	24	9	15	460	9.1	43	150	9.1	43	460	23	43
M-30	22	6	16	240	3.6	43	240	23	33	240	3.6	43
N-26	23	7	16	460	3.6	23	460	9.1	93	93	3.6	23
N-29	22	6	16	460	3.6	33	93	23	43	460	3.6	23
N-21	20	6	14	460	3.6	43	460	3.6	33	240	7.3	43
O-27	12	5	7	93	3.6	23	93	15	23	93	3.6	9.1
O-29	21	6	15	150	3.6	23	150	9.1	68	150	3.6	23
O-30	21	6	15	460	3.6	23	43	3.6	23	460	3.6	23
O-32	18	5	13	460	3.0	23	93	15	23	460	3.0	23
O-34	25	9	16	+1100	3.6	43	460	9.1	23	+1100	3.6	43
P-28	12	5	7	93	7.3	23	93	7.3	23	93	9.1	23
P-33	22	6	16	240	-3.0	23	43	-3.0	6.4	240	3.0	33
P-34	24	8	16	1100	-3.0	23	93	-3.0	16	1100	9.1	23
P-35	27	10	17	460	3.6	43	460	3.6	23	460	3.6	75
Q-30	13	6	7	93	9.1	23	93	9.1	23	43	9.1	23
Q-32	22	7	15	240	9.1	23	23	9.1	23	240	9.1	43
Q-36	26	8	18	1100	-3.0	23	43	-3.0	23	1100	3.6	23
Q-37	27	11	16	+1100	3.6	23	460	3.6	15	+1100	9.1	33
R-32	5	1	4	43	3.6	21	21	21	21	43	3.6	16
R-34	23	8	15	240	7.3	23	43	23	23	240	7.3	23

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						HAMPTON FLATS (Contd.)						
R-37	27	9	18	1100	-3.0	23	150	-3.0	23	1100	-3.0	23
R-38	28	12	16	≮1100	3.6	43	1100	3.6	23	≮1100	3.6	43
S-32	15	7	8	93	3.0	23	93	23	23	93	3.0	22
S-35	26	8	18	1100	3.6	23	240	9.1	23	1100	3.6	23
S-38	29	14	15	460	3.6	23	150	3.6	23	460	3.6	39
T-35	15	6	9	1100	9.1	23	150	23	59	1100	9.1	23
T-36	28	11	17	1100	3.6	23	43	23	23	1100	3.6	43
T-38	27	10	17	≮1100	3.6	23	93	7.3	23	≮1100	3.6	43
T-40	28	14	14	≮1100	3.6	43	150	3.6	33	≮1100	9.1	93
U-37	15	7	8	1100	3.6	43	93	15	43	1100	3.6	58
U-39	28	11	17	4600	-3.0	43	75	-3.0	23	4600	9.1	75
V-35	17	10	7	93	3.6	23	93	15	23	93	3.6	23
V-41	28	14	14	1100	11	93	1100	15	59	1100	11	240
W-36	17	9	8	≮1100	9.1	23	240	14	23	≮1100	9.1	33
W-38	14	7	7	460	9.1	43	460	23	43	460	9.1	43
W-39	18	8	10	1500	7.3	43	460	7.3	41	1500	9.1	59
W-40	24	10	14	≮1100	9.1	23	93	9.1	23	≮1100	9.1	23
W-36	19	11	8	460	9.1	23	460	9.1	23	240	15	33
X-42	40	20	20	4600	9.1	43	≮1100	9.1	59	4600	9.1	43
X-43	22	10	12	≮1100	7.3	68	≮1100	23	93	1100	7.3	43
Y-40	20	12	8	≮1100	9.1	43	≮1100	9.1	43	93	9.1	33
Y-42	19	11	8	1100	9.1	43	1100	9.1	39	240	9.1	68

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						NORTH SHORE INLETS						
K-25	10	-	10	930	23	93	-	-	-	930	23	93
K-26	10	-	10	+1100	7.3	23	-	-	-	+1100	7.3	23
N-33	10	-	10	+11000	150	1520	-	-	-	+11000	150	1520
0-36	10	-	10	460000	1400	+11000	-	-	-	460000	1400	+11000
0-37	8	-	8	+11000	360	1660	-	-	-	+11000	360	1660
S-40	9	-	9	+110000	91	930	-	-	-	+110000	91	930
						NORFOLK HARBOR CHANNEL - ELIZABETH RIVER						
U-29	15	9	6	1100	23	43	1100	23	43	93	43	68
X-28	9	5	4	460	43	150	460	43	150	430	43	152
X-29	9	5	4	1100	43	93	460	43	150	1100	43	68
BB-29	16	6	10	1100	23	240	1100	23	670	1100	43	335
EE-29	17	6	11	1100	23	93	240	23	43	1100	43	150
JJ-29	17	6	11	+1100	23	240	+1100	93	238	1100	23	240
NN-29	19	8	11	24000	-30	230	24000	-30	345	4600	43	93
QQ-28	19	6	13	46000	36	460	46000	36	445	11000	43	930
TT-28	6	3	3	+11000	91	1620	2300	31	430	+11000	930	4300
TT-28A	6	3	3	4300	-30	430	430	-30	430	4300	230	+1100
UU-27	6	3	3	+11000	230	2370	4300	230	430	+11000	230	4300
VV-26	6	3	3	+11000	150	965	1500	150	430	+11000	230	9300
						LAFAYETTE RIVER						
KK-22	9	4	5	+11000	230	930	4300	430	930	+11000	230	930
KK-23	9	4	5	11000	150	430	2300	230	330	11000	150	460

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
LAFAYETTE RIVER (Contd.)												
KK-24	11	4	7	2400	230	930	2400	230	1615	2100	230	460
KK-25	11	4	7	4300	93	460	4300	93	335	2400	93	1100
LL-26	12	4	8	1500	93	445	1500	93	670	⁄1100	150	445
MM-21	9	3	6	2400	150	430	930	230	750	2400	150	430
NN-21	9	3	6	4300	230	930	1500	230	930	4300	430	695
NN-27	12	4	8	4600	43	460	930	93	350	4600	43	695
OO-19	9	3	6	110000	430	1500	2400	430	2400	110000	430	1215
OO-20	9	3	6	7500	43	930	2400	430	930	7500	43	580
CRANEY ISLAND FLATS												
DD-43	11	4	7	240	3.6	23	240	9.1	43	93	3.6	23
EE-39	14	6	8	240	3.6	43	93	23	59	240	3.6	23
EE-41	11	5	6	43	3.6	23	43	9.1	23	43	3.6	33
FF-32	13	6	7	240	3.6	43	230	15	43	240	3.6	43
FF-35	14	7	7	93	3.6	23	93	9.1	23	93	3.6	23
FF-37	13	6	7	150	3.6	43	43	23	41	150	3.6	43
GG-43	8	4	4	150	3.6	41	43	3.6	39	150	9.1	69
GG-45	8	3	5	240	3.6	23	43	3.6	23	240	3.6	23
HH-32	15	7	8	430	9.1	43	430	16	43	43	9.1	33
HH-34	15	7	8	93	-3.0	23	93	9.1	23	93	-3.0	43
HH-37	13	5	8	240	3.6	23	240	9.1	43	93	3.6	23
HH-39	13	5	8	93	9.1	23	43	23	23	93	9.1	33
HH-41	7	3	4	93	-3.0	23	43	9.1	23	93	-3.0	33
HH-46	9	4	5	93	3.6	15	15	7.3	9.1	93	3.6	43
II-35	16	7	9	120	-3.0	23	43	3.6	23	120	-3.0	43

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						CRANEY ISLAND FLATS (Contd.)						
II-37	16	7	9	75	-3.0	23	43	9.1	23	75	-3.0	23
II-39	16	7	9	93	-3.0	23	43	7.3	9.1	93	-3.0	23
II-41	9	4	5	93	3.6	9.1	23	3.6	9.1	93	9.1	23
II-43	8	3	5	240	9.1	23	93	9.1	23	240	9.1	23
JJ-31	17	8	9	+1100	9.1	93	430	9.1	33	+1100	43	240
JJ-33	17	8	9	460	-3.0	39	93	-3.0	23	460	23	43
JJ-44	9	4	5	150	3.6	23	93	3.6	14	150	3.6	23
KK-37	16	7	9	93	9.1	23	93	9.1	15	93	9.1	39
KK-39	16	7	9	120	-3.0	9.1	43	3.6	9.1	120	-3.0	9.1
KK-41	9	4	5	93	-3.0	9.1	43	9.1	9.1	93	-3.0	23
KK-42	9	4	5	75	3.6	9.1	23	7.3	9.1	75	3.6	23
LL-30	18	6	12	+11000	23	150	150	23	68	+11000	93	240
LL-31	17	8	9	+1100	3.6	23	93	3.6	23	+1100	23	43
LL-33	17	8	9	240	3.6	23	23	3.6	23	240	9.1	43
LL-35	16	7	9	93	3.6	23	43	15	23	93	3.6	39
						FORT MONROE						
G-20	6	1	5	23	3.6	9.1	3.6	3.6	3.6	23	9.1	9.1
I-21	5	1	4	23	-3.0	9.1	-3.0	-3.0	-3.0	23	3.6	12
K-21	6	1	5	93	3.6	16	23	23	23	93	3.6	9.1
L-22	6	1	5	240	7.3	16	7.3	7.3	7.3	240	9.1	23
N-22	6	1	5	93	9.1	19	15	15	15	93	9.1	23
O-19	5	1	4	240	23	75	23	23	23	240	23	158

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						MOUTH OF ROADS						
N-25	34	14	20	430	9.1	43	150	9.1	33	430	15	43
P-25	34	16	18	460	7.3	43	460	7.3	43	460	9.1	68
R-24	34	18	16	1100	3.6	93	150	3.6	43	1100	23	240
T-24	33	13	20	1100	3.6	43	1100	3.6	43	1100	3.6	240
U-24	33	17	16	460	7.3	93	460	9.1	43	460	7.3	240
V-24	33	18	15	1100	9.1	240	1100	9.1	240	1100	9.1	240
						WILLOUGHBY BANK						
R-13	11	4	7	93	3.6	23	43	23	23	93	3.6	23
R-14	10	3	7	93	3.6	29	93	43	75	43	3.6	9.1
R-15	10	3	7	43	-3.0	31	43	23	43	43	-3.0	31
R-16	12	4	8	150	3.6	16	23	3.6	9.1	150	7.3	43
R-17	13	4	9	240	3.6	23	93	3.6	12	240	9.1	43
R-18	15	6	9	1100	9.1	43	93	9.1	43	1100	9.1	43
R-19	15	6	9	240	3.6	23	43	3.6	23	240	9.1	43
R-20	15	6	9	460	3.6	23	93	9.1	23	460	3.6	23
R-22	15	6	9	+1100	3.6	43	240	3.6	23	+1100	9.1	93
S-16	16	7	9	460	3.0	33	240	3.0	43	460	9.1	23
S-17	16	8	8	1100	3.6	43	93	3.6	68	1100	3.6	33
S-18	14	6	8	1100	-3.0	43	460	3.6	33	1100	-3.0	43
S-19	15	7	8	460	3.6	43	460	3.6	23	240	9.1	68
S-20	15	7	8	460	3.6	43	75	3.6	15	460	9.1	68
S-21	16	7	9	1100	-3.0	93	93	-3.0	43	1100	15	240

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				* All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
						WILLOUGHBY BANK (Contd.)						
T-16	16	9	7	240	3.6	19	240	3.6	23	43	3.6	15
T-17	17	9	8	240	-3.0	43	240	-3.0	43	93	3.6	43
T-18	15	8	7	240	3.0	43	240	3.0	26	240	9.1	43
T-19	17	9	8	240	-3.0	43	240	-3.0	23	240	3.6	43
T-20	17	9	8	1100	-3.0	43	210	-3.0	9.1	1100	9.1	84
T-21	18	9	9	1100	3.6	68	1100	3.6	43	1100	9.1	93
U-16	15	8	7	460	-3.0	9.1	93	-3.0	9.1	460	7.3	43
U-18	15	8	7	240	-3.0	23	43	3.6	23	240	-3.0	43
U-19	15	8	7	460	-3.0	23	93	-3.0	12	460	3.6	75
V-16	13	6	7	240	-3.0	43	93	-3.0	26	240	3.6	43
V-17	14	7	7	460	-3.0	43	93	-3.0	23	460	3.6	150
W-15	6	4	2	23	3.6	13	23	3.6	6.4	23	23	23
Y-14	6	4	2	39	3.6	23	39	3.6	19	23	23	23
						JAMES RIVER						
C-63	10	5	5	93	-3.0	9.1	93	9.1	9.1	43	-3.0	9.1
D-61	9	5	4	93	3.6	23	23	9.1	23	93	3.6	29
F-58	13	7	6	1100	3.6	23	1100	3.6	43	240	15	23
H-56	18	11	7	1100	9.1	43	1100	23	43	93	9.1	43
H-57	18	11	7	1100	3.6	23	1100	9.1	23	43	3.6	23
H-62	11	5	6	43	3.6	23	43	9.1	23	43	3.6	23
I-54	20	11	9	460	3.6	43	460	9.1	43	460	3.6	43
J-53	9	5	4	+1100	3.6	43	+1100	3.6	460	93	9.1	23
J-55	8	4	4	460	3.6	33	460	21	93	43	3.6	16

TABLE 3 - SURVEY OF HAMPTON ROADS SHELLFISH AREAS - SUMMARY OF BACTERIOLOGICAL RESULTS BY TIDAL CYCLES

Sample Point	Number of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
							JAMES RIVER (Contd.)					
J-58	19	9	10	1100	3.6	23	1100	3.6	23	93	9.1	43
J-59	21	10	11	460	3.6	23	460	3.6	43	460	9.1	23
K-51	18	10	8	+1100	3.6	122	+1100	3.6	695	1100	9.1	59
K-56	21	9	12	+1100	-3.0	43	240	9.1	43	+1100	-3.0	33
K-65	5	2	3	43	3.6	7.3	15	3.6	9.3	43	3.6	7.3
L-54	19	9	10	460	3.6	23	460	9.1	39	240	3.6	23
M-53	21	10	11	+1100	9.1	43	+1100	9.1	43	460	9.1	43
M-63	5	2	3	23	3.6	23	23	9.1	16	23	3.6	23
O-50	20	10	10	1100	23	93	1100	23	79	460	43	93
O-61	7	3	4	43	9.1	23	43	9.1	23	43	9.1	31
P-57	10	5	5	240	3.6	15	240	9.1	9.1	93	3.6	23
S-49	21	10	11	1100	9.1	43	1100	9.1	43	1100	23	93
S-54	10	4	6	150	9.1	23	150	9.1	68	43	9.1	16
W-47	22	8	14	240	23	75	240	43	75	240	23	68
W-51	10	4	6	93	3.6	23	93	23	33	43	3.6	16
Z-50	10	4	6	93	3.6	23	43	23	33	93	3.6	13
DD-45	11	4	7	150	9.1	23	93	23	33	150	9.1	23

Note:

+ Indicates indeterminate but greater than value shown.

- Indicates indeterminate but less than value shown.

Several figures have been prepared to show the coliform densities of the waters for the different tidal phases. The coliform densities are based on the medians of the results for the samples taken at each sample point under the conditions noted.

Figures 3 and 4 show the results for all samples taken during the survey, Figure 3 covering the Hampton Roads Section and Figure 4 the James River Section. These coliform density charts indicate that the median coliform MPN's for practically all shellfish growing areas are within the limit allowed for harvesting market shellfish. It should be realized that conformity to the prescribed bacteriological quality limits of the overlying waters is not in itself sufficient to ensure approval of an area for taking market shellfish. Two relatively small areas on Hampton Flats do not meet this standard of bacteriological water quality. One of these areas is off the mouth of Hampton Creek and the other is just inshore from Newport News Bar. The only area on Craney Island Flats where the bacteriological quality of the water would not permit the taking of market oysters is a relatively narrow strip on the east adjacent to the Norfolk Harbor Channel. The relatively heavy pollution coming from the Elizabeth and Lafayette Rivers and the Norfolk Harbor Channel is carried around the shoreline north of Sewell Point to Willoughby Spit and affects the western portion of Willoughby Bank. The pollution resulting from the septic tank effluent discharged at the east end of the James River Bridge is sufficient to make impossible the direct marketing of shellfish from the flats on the east side of the river between Newport News and Hilton Village. This area has been restricted since September, 1926, but it would appear possible that it might be released when this sewage flow is diverted to the Boat Harbor sewage treatment plant.

Figures 5 and 6 show the median results for ebb tide samples while Figures 7 and 8 show the flood tide results. Figures 5 and 7 indicate how the pollution from the Norfolk-Portsmouth area is carried by the ebb tide in the main channel between Old Point Comfort and Fort Wool and over a portion of Willoughby Bank into the open waters of Chesapeake Bay and is swept back on flood tide by comparatively unpolluted water from the Bay. Figure 5 also shows how ebb tides carry effluent from Boat Harbor Sewage Treatment to the north of Newport News Bar and disperse it over the flats.

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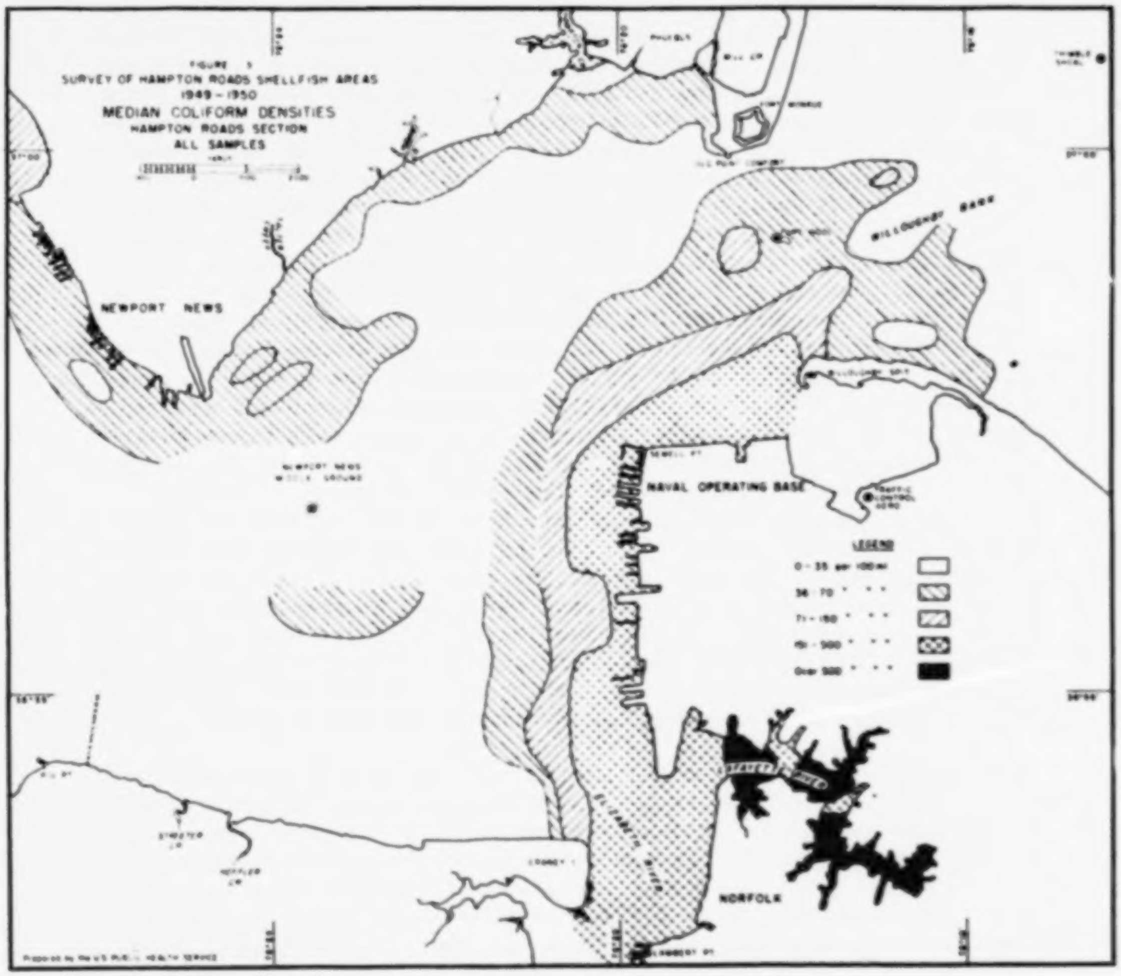

FIGURE 3
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
MEDIAN COLIFORM DENSITIES
HAMPTON ROADS SECTION
ALL SAMPLES

NEWPORT NEWS
NAVAL OPERATING BASE
NORFOLK
WILLOUGHBY BANK
WILLOUGHBY SPIT
ELIZABETH RIVER
NEWPORT NEWS MIDDLE GROUND
FORT MONROE
OLD POINT COMFORT
PHOEBUS
THIMBLE SHOAL
TRAFFIC CONTROL AERO
SEWELLS PT
LAMBERT PT
CRANEY I.
STREETER CR.
HOFFLER CR.
LEGEND
0 - 35 per 100 ml ☐
36 - 70 " " " ▧
71 - 150 " " " ▨
151 - 500 " " " ▩
Over 500 " " " ■
Prepared by the U.S. Public Health Service

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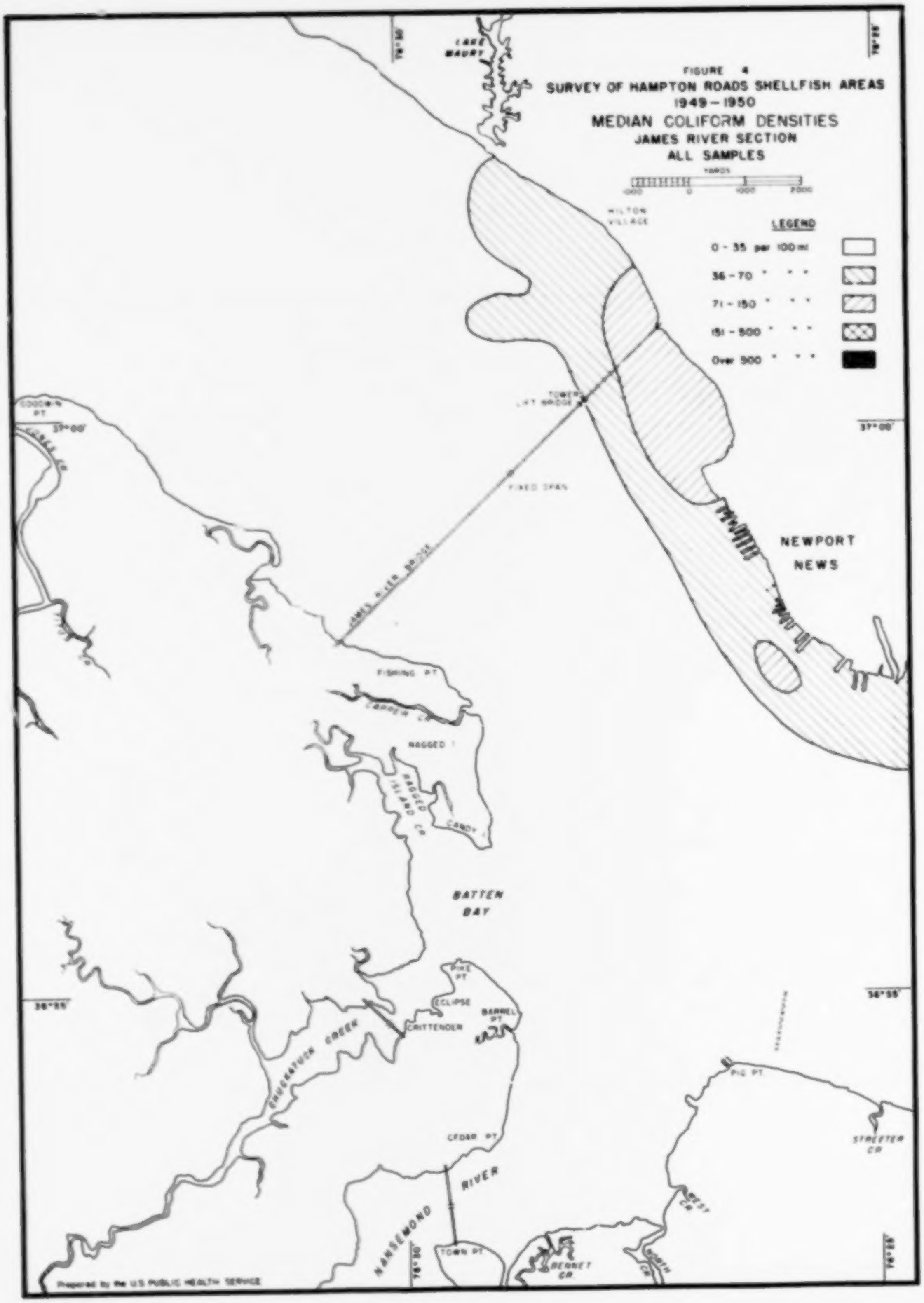

FIGURE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS

1949 – 1950

MEDIAN COLIFORM DENSITIES

JAMES RIVER SECTION

ALL SAMPLES

YARDS
1000
0
1000
2000
LEGEND
0 - 35 per 100 ml ☐
36 - 70 " " " ▨
71 - 150 " " " ▨
151 - 500 " " " ▩
Over 500 " " " ■
LAKE MAURY
HILTON VILLAGE
TOWER LIFT BRIDGE
FIXED SPAN
JAMES RIVER BRIDGE
NEWPORT NEWS
GOODWIN PT
37°00'
FISHING PT
CARRER CR
RAGGED I
RAGGED ISLAND CR
CANDY I
BATTEN BAY
PIKE PT
ECLIPSE
BARREL PT
CRITTENDEN
CHUCKATUCK CREEK
CEDAR PT
NANSEMOND RIVER
TOWN PT
BENNET CR
WEST CR
NORTH CR
PIG PT
STREETER CR
36°55'
76°30'
76°25'
Prepared by the U.S. PUBLIC HEALTH SERVICE

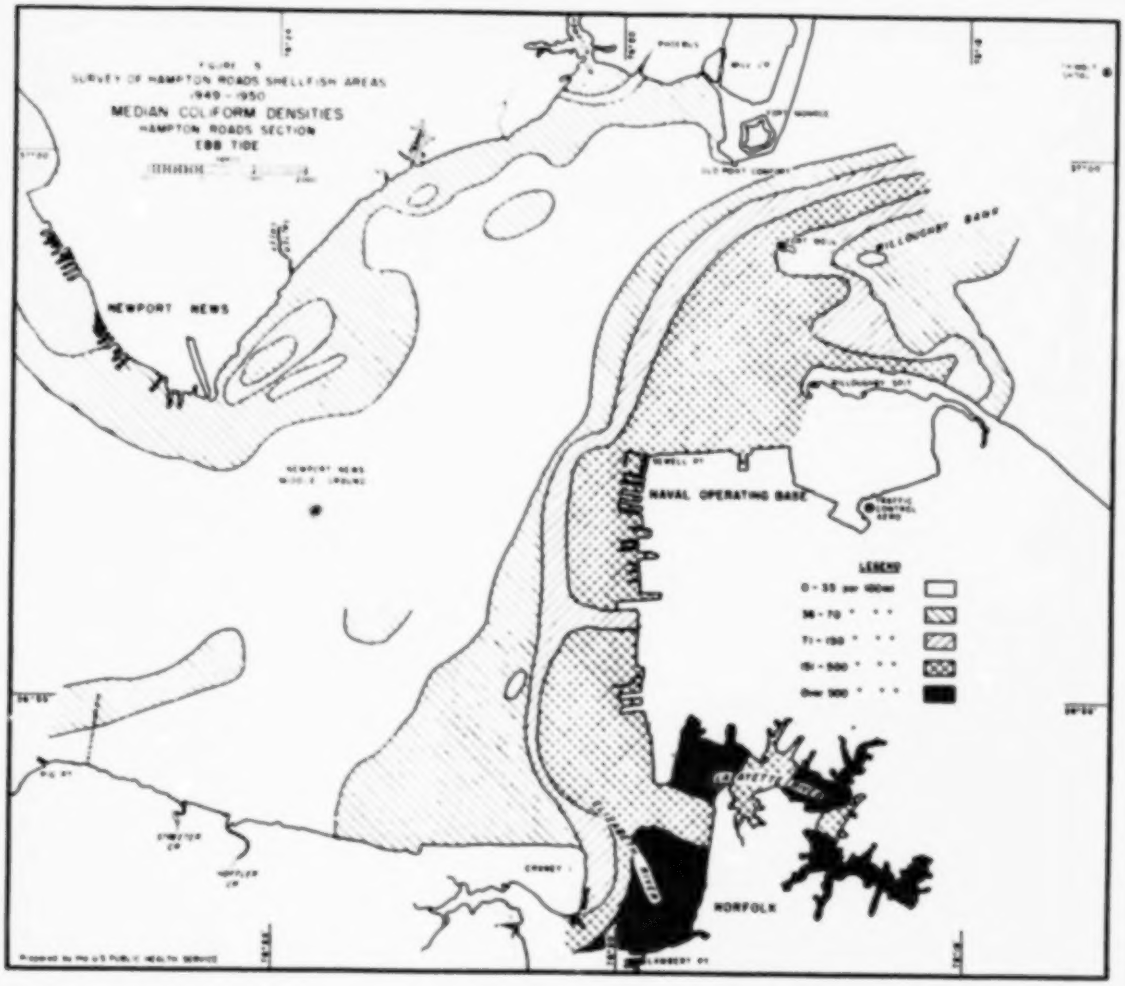

FIGURE 5
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 - 1950
MEDIAN COLIFORM DENSITIES
HAMPTON ROADS SECTION
EBB TIDE

LEGEND
0 - 35 per 100ml ☐
36 - 70 " " " ▧
71 - 150 " " " ▨
151 - 500 " " " ▩
Over 500 " " " ■
NEWPORT NEWS
NEWPORT NEWS MIDDLE GROUND
OLD POINT COMFORT
FORT MONROE
WILLOUGHBY BAR
WILLOUGHBY SPIT
SEWELLS PT
NAVAL OPERATING BASE
TRAFFIC CONTROL AERO
NORFOLK
CRANEY I
STREETER CR
HOFFLER CR
Prepared by the U.S. PUBLIC HEALTH SERVICE

47

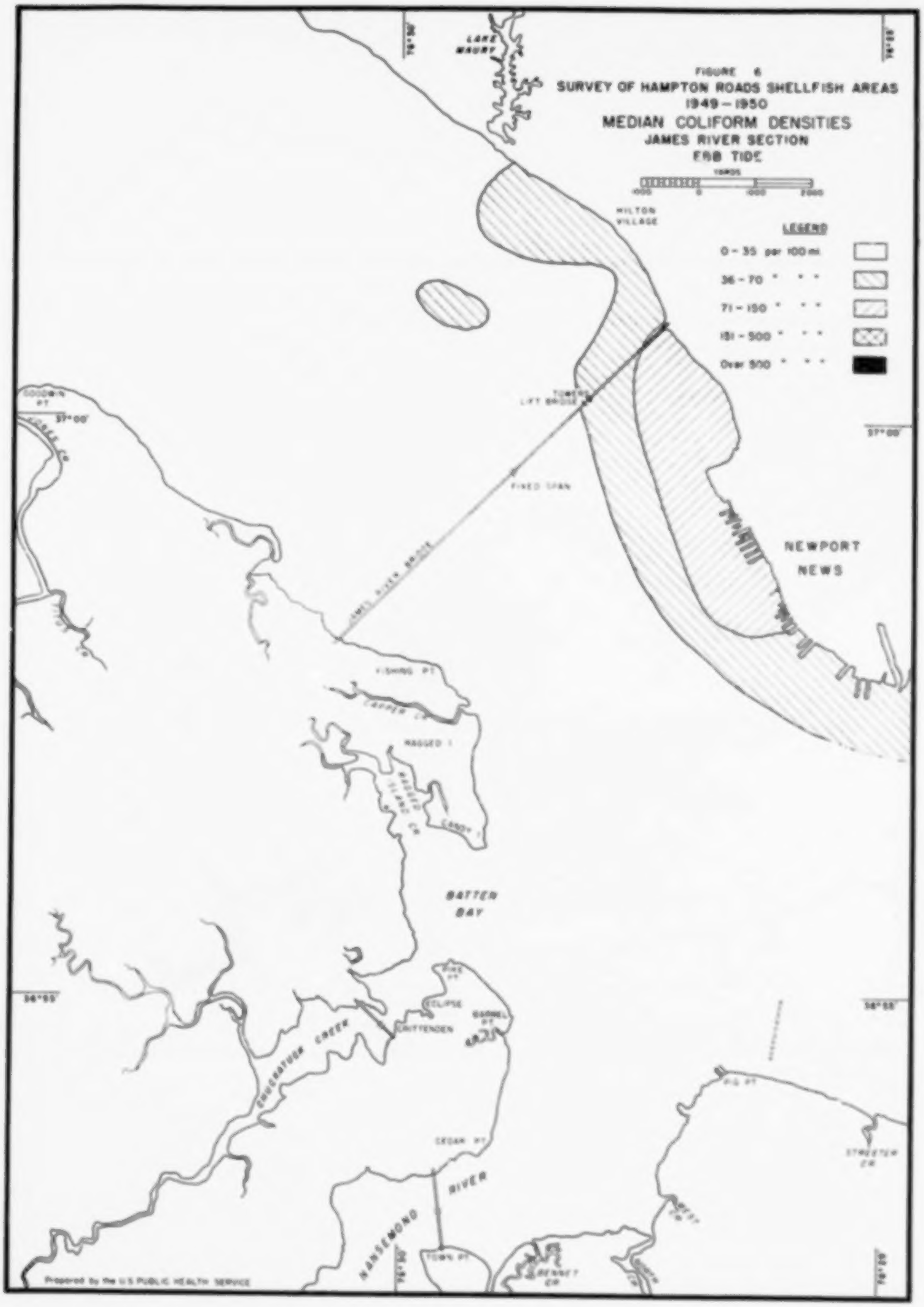

FIGURE 6
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
MEDIAN COLIFORM DENSITIES
JAMES RIVER SECTION
EBB TIDE

YARDS
1000
0
1000
2000
LEGEND
0 – 35 per 100 ml
36 – 70 " " "
71 – 150 " " "
151 – 500 " " "
Over 500 " " "
LAKE MAURY
HILTON VILLAGE
TOWERS
LIFT BRIDGE
FIXED SPAN
JAMES RIVER BRIDGE
NEWPORT NEWS
GOODWIN PT
37°00'
FISHING PT
RAGGED I
RAGGED ISLAND CR
CANDY I
BATTEN BAY
PIKE PT
ECLIPSE
CRITTENDEN
CARDWELL PT
CHUCKATUCK CREEK
CEDAR PT
NANSEMOND RIVER
TOWN PT
BENNET CR
PIG PT
STREETER CR
36°55'
76°30'
76°25'
Prepared by the U.S. PUBLIC HEALTH SERVICE

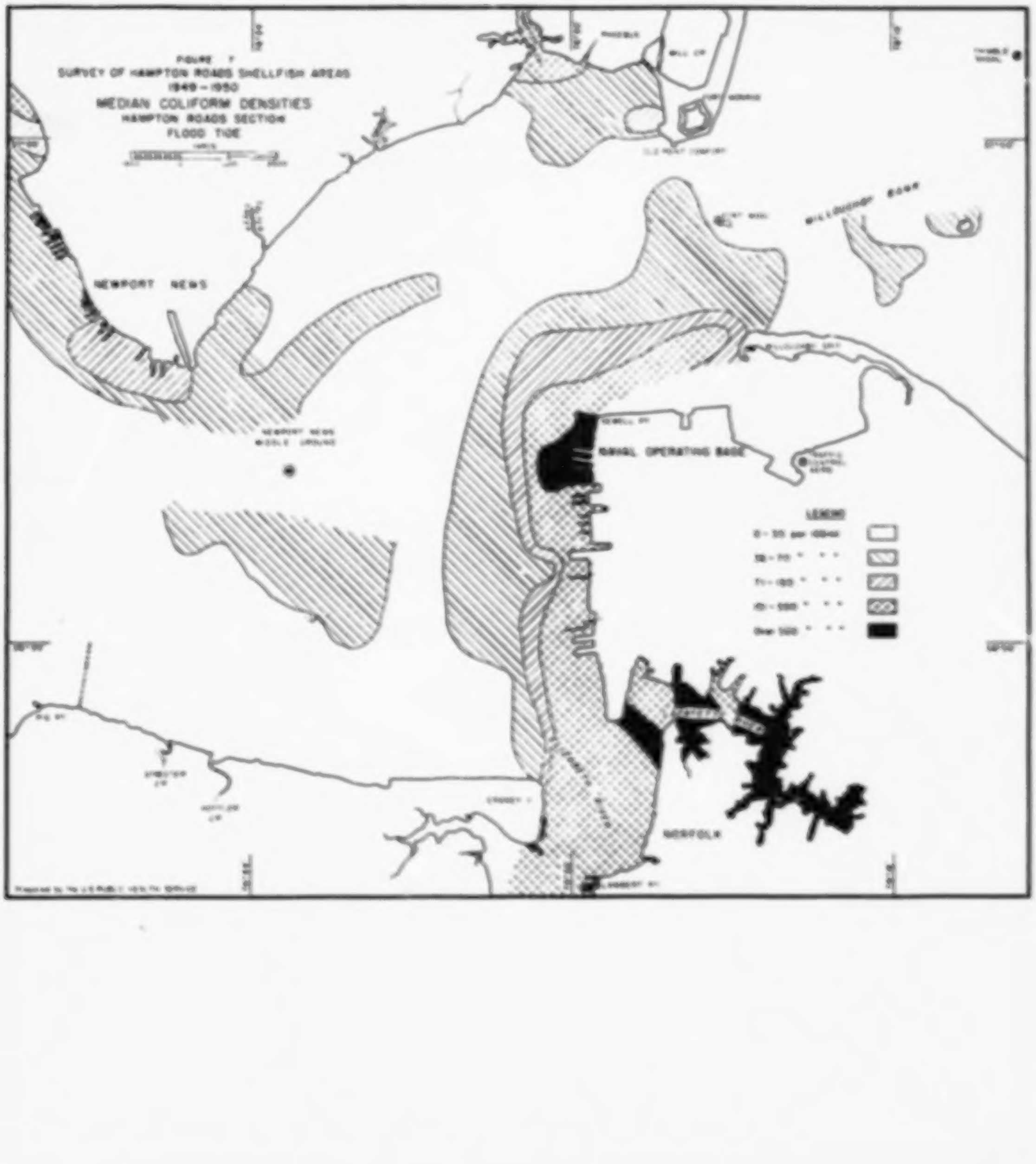
FIGURE 7
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
MEDIAN COLIFORM DENSITIES
HAMPTON ROADS SECTION
FLOOD TIDE
NEWPORT NEWS
NEWPORT NEWS MIDDLE GROUND
WILLOUGHBY BANK
WILLOUGHBY SPIT
SEWELL PT
NAVAL OPERATING BASE
LEGEND
0 – 30 per 100ml
31 – 70 " " "
71 – 100 " " "
101 – 500 " " "
Over 500 " " "
NORFOLK
Prepared by the U.S. PUBLIC HEALTH SERVICE

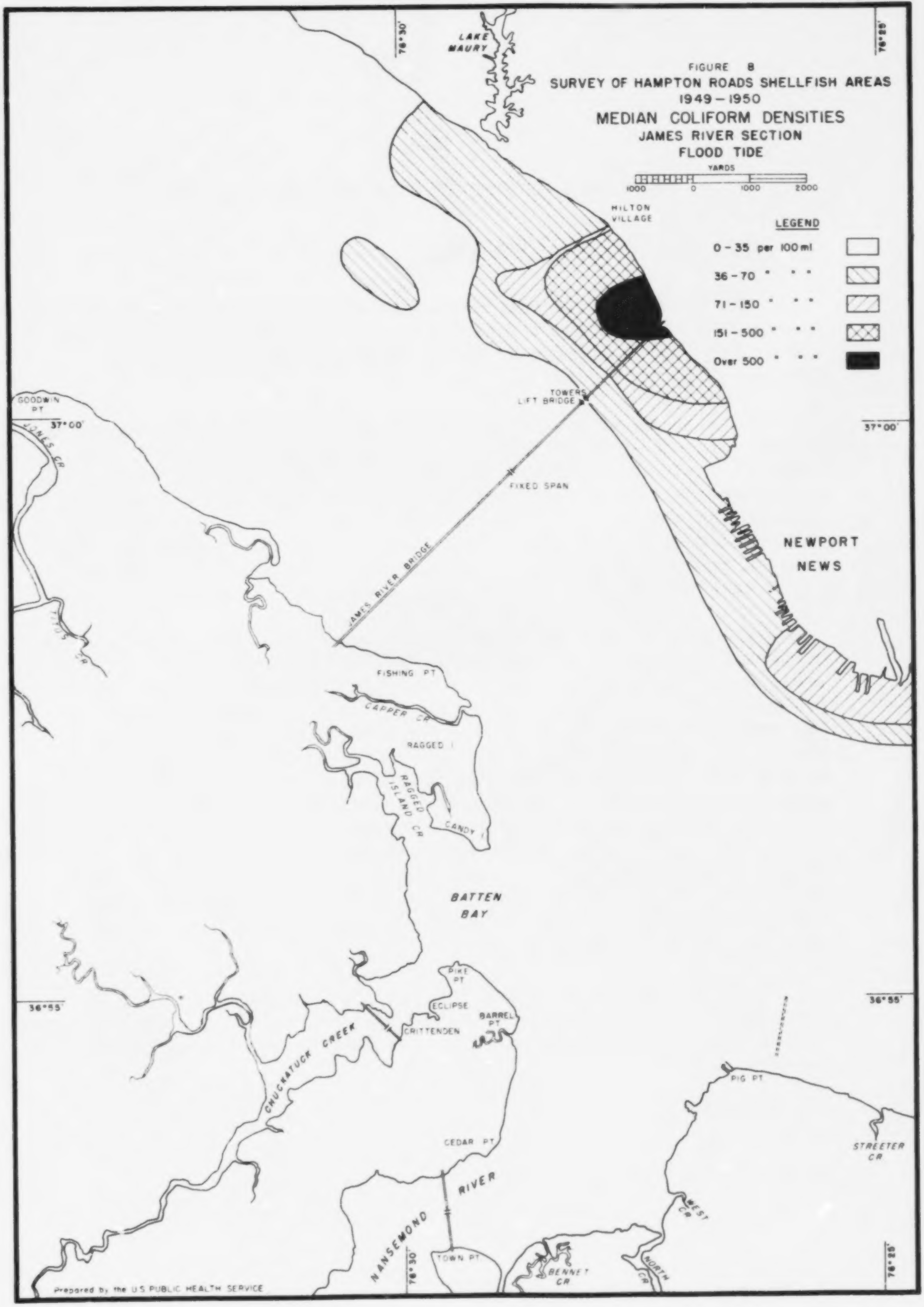

FIGURE 8
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
MEDIAN COLIFORM DENSITIES
JAMES RIVER SECTION
FLOOD TIDE

LEGEND

- 0 – 35 per 100 ml ☐
- 36 – 70 " " " ▨
- 71 – 150 " " " ▨
- 151 – 500 " " " ▦
- Over 500 " " " ■

Prepared by the U.S. PUBLIC HEALTH SERVICE

76°30'
76°25'
37°00'
36°55'
YARDS
1000
0
1000
2000
LAKE MAURY
HILTON VILLAGE
TOWERS
LIFT BRIDGE
FIXED SPAN
JAMES RIVER BRIDGE
NEWPORT NEWS
GOODWIN PT
JONES CR
TITUS CR
FISHING PT
CAPPER CR
RAGGED I
RAGGED ISLAND CR
CANDY I
BATTEN BAY
PIKE PT
ECLIPSE
CRITTENDEN
BARREL PT
CHUCKATUCK CREEK
CEDAR PT
NANSEMOND RIVER
TOWN PT
PIG PT
STREETER CR
WEST CR
NORTH CR
BENNET CR

IX

COMPARISON OF RESULTS WITH PREVIOUS SURVEYS

4. Comparison with 1934 Conditions

The only previous comprehensive bacteriological survey of the waters of Hampton Roads and vicinity was the 1934 survey made by the Public Health Service to which reference has been made in Section II of this report.

The results of the samples taken on this survey were reported as per cent of positive tubes in the 1.0 ml portion for all samples taken at a given point, the method used at that time for rating the bacterial quality of shellfish waters. In addition to reporting findings on the basis of per cent of positive tubes, the coliform MPN per 100 ml was determined for each sample and the maximum and average (presumably arithmetic average) values for each sample point were presented. Median values were not determined.

It appeared that the most satisfactory method of comparing the bacterial quality of the waters in 1934 and at the present time would be on the basis of the average M.P.N., realizing that the average would not correspond to the median. Accordingly, the average MPN for each sample point in the 1934 survey was plotted on charts and coliform density curves drawn. Similar average density curves were prepared of the results obtained during the present survey. Comparison of the charts clearly reveals the changes that have occurred in water quality. In comparing the results obtained during the two surveys, it is important to remember that the population of the area has increased considerably since 1934 and that without the intercepting sewers and treatment plants constructed since 1945 the water quality would undoubtedly have been poorer in 1949-1950 than it was in 1934.

Figures 9 and 10 show the average coliform densities for the James River sections for 1934 and 1949-50 respectively. Figures 11 and 12 present similar data for the Hampton Roads section of the area.

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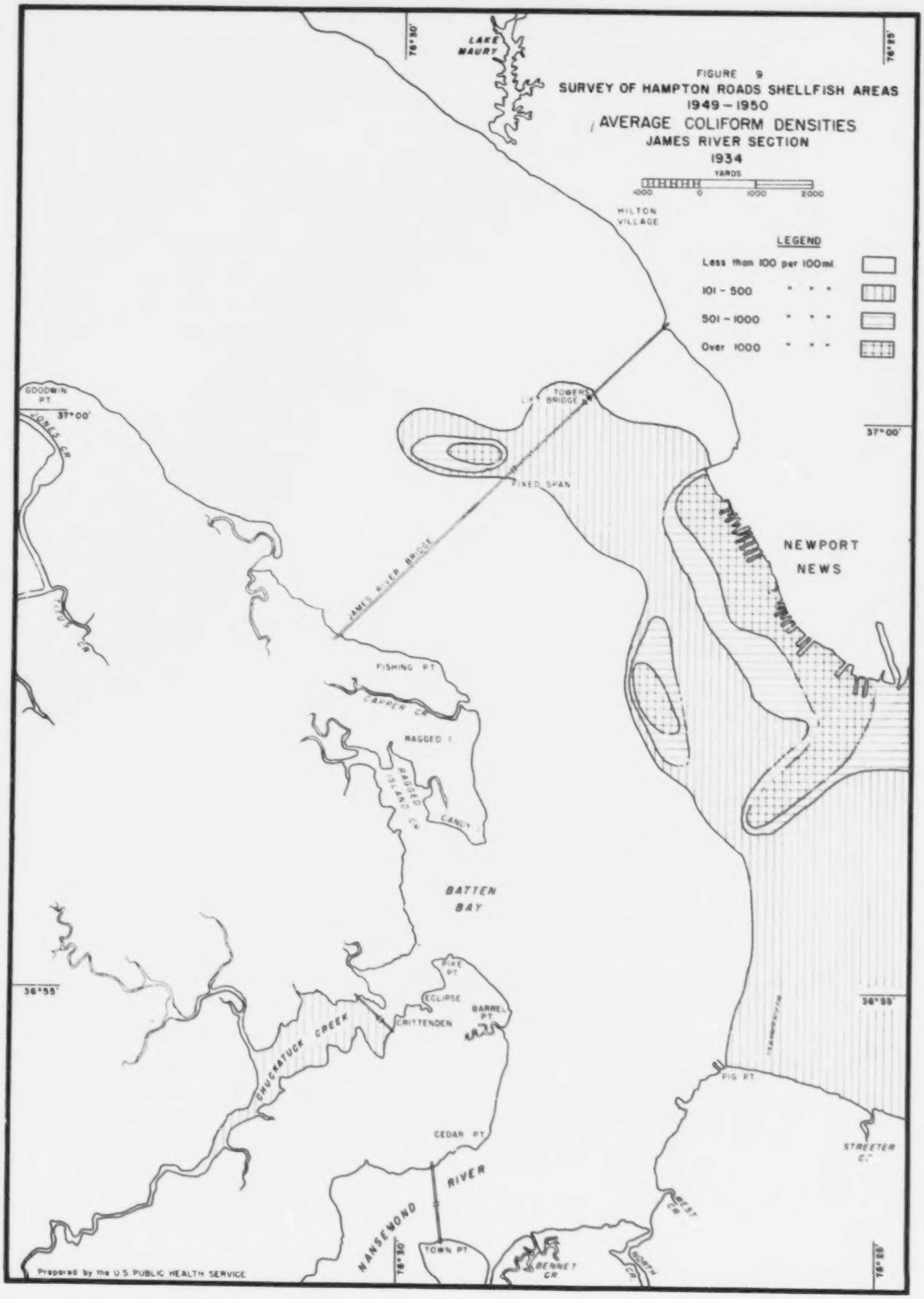

FIGURE 9

SURVEY OF HAMPTON ROADS SHELLFISH AREAS

1949 – 1950

AVERAGE COLIFORM DENSITIES

JAMES RIVER SECTION

1934

YARDS
1000
0
1000
2000
LEGEND
Less than 100 per 100ml
101 - 500 " " "
501 - 1000 " " "
Over 1000 " " "
76°30'
76°25'
37°00'
36°55'
LAKE MAURY
HILTON VILLAGE
GOODWIN PT
JONES CR
TITUS CR
TOWERS
LIFT BRIDGE
FIXED SPAN
JAMES RIVER BRIDGE
NEWPORT NEWS
FISHING PT
CARPER CR
RAGGED I.
RAGGED ISLAND CR
CANDY
BATTEN BAY
PIKE PT
ECLIPSE
BARREL PT
CRITTENDEN
CHUCKATUCK CREEK
PIG PT
CEDAR PT
NANSEMOND RIVER
TOWN PT
BENNET CR
NORTH CR
WEST CR
STREETER CR
Prepared by the U.S. PUBLIC HEALTH SERVICE

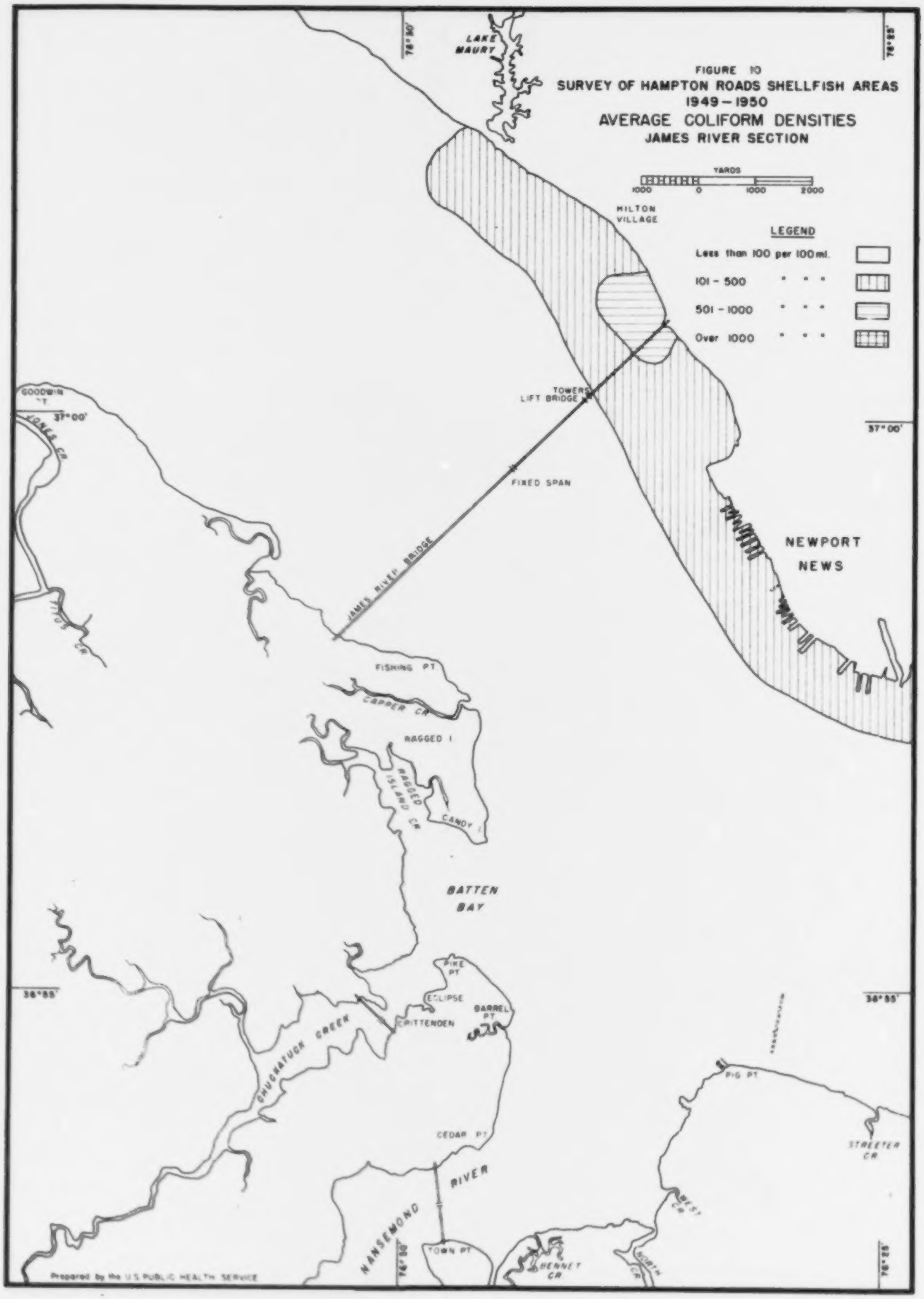

FIGURE 10
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
AVERAGE COLIFORM DENSITIES
JAMES RIVER SECTION

YARDS
1000
0
1000
2000
LEGEND
Less than 100 per 100 ml.
101 – 500 " " "
501 – 1000 " " "
Over 1000 " " "
LAKE MAURY
76°30'
76°25'
MILTON VILLAGE
TOWERS
LIFT BRIDGE
37°00'
FIXED SPAN
JAMES RIVER BRIDGE
NEWPORT NEWS
GOODWIN "T"
JONES CR
TITUS CR
FISHING PT
CAPPER CR
RAGGED I
RAGGED ISLAND CR
CANDY I
BATTEN BAY
36°55'
PIKE PT
ECLIPSE
BARREL PT
CRITTENDEN
CHUCKATUCK CREEK
PIG PT
STREETER CR
CEDAR PT
NANSEMOND RIVER
TOWN PT
BENNET CR
WEST CR
NORTH CR
Prepared by the U.S. PUBLIC HEALTH SERVICE

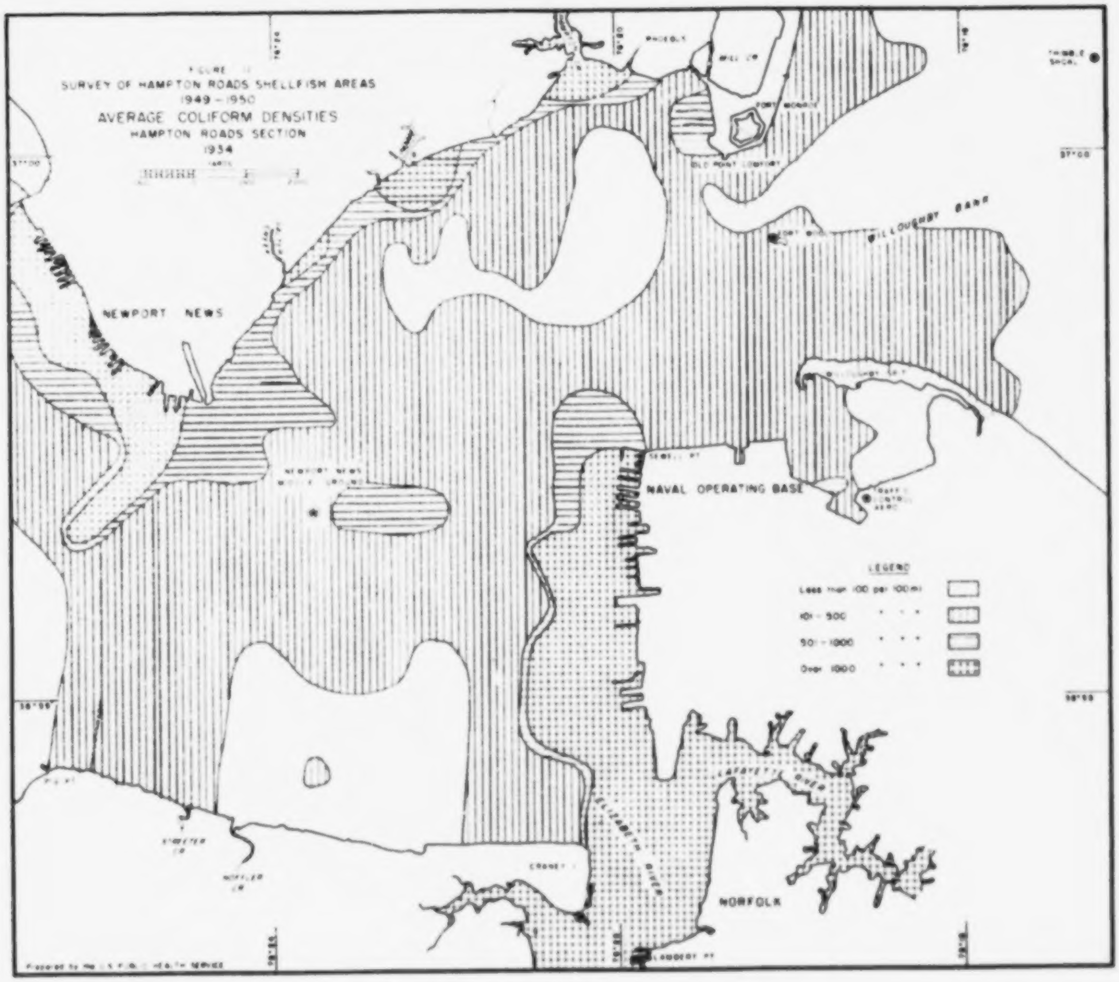

FIGURE 11
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
AVERAGE COLIFORM DENSITIES
HAMPTON ROADS SECTION
1934

YARDS
NEWPORT NEWS
NAVAL OPERATING BASE
NORFOLK
WILLOUGHBY BANK
OLD POINT COMFORT
FORT MONROE
MILL CR.
PHOEBUS
THIMBLE SHOAL
ELIZABETH RIVER
LAFAYETTE RIVER
CRANEY I.
STREETER CR.
HOFFLER CR.
SEWELLS PT.
LAMBERTS PT.
37°00'
36°55'
LEGEND
Less than 100 per 100 ml
101 – 500 " " "
501 – 1000 " " "
Over 1000 " " "
Prepared by the U.S. PUBLIC HEALTH SERVICE

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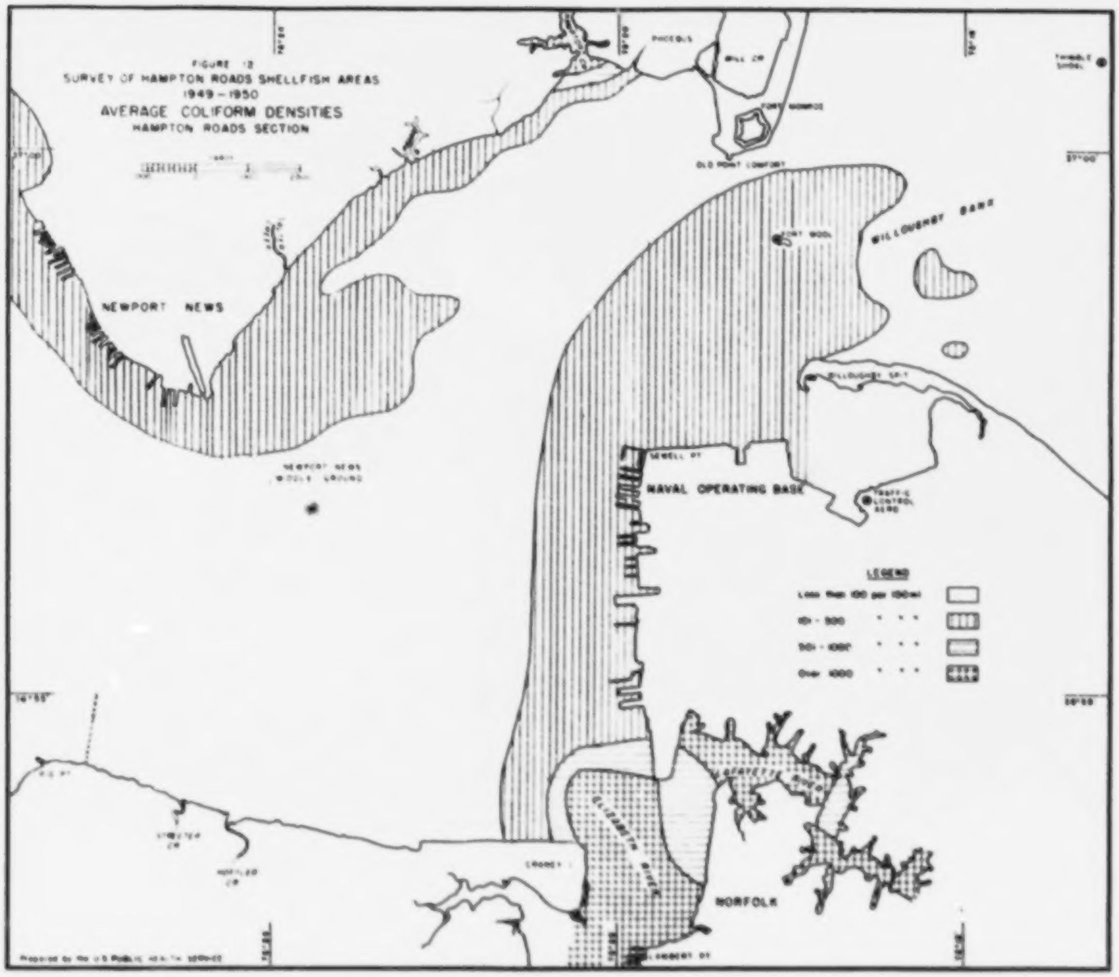

FIGURE 12
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
AVERAGE COLIFORM DENSITIES
HAMPTON ROADS SECTION

PHOEBUS
MILL CR
FORT MONROE
OLD POINT COMFORT
THIMBLE SHOAL
FORT WOOL
WILLOUGHBY BANK
NEWPORT NEWS
NEWPORT NEWS MIDDLE GROUND
WILLOUGHBY SPIT
SEWELL PT
NAVAL OPERATING BASE
TRAFFIC CONTROL AERO
LEGEND
Less than 100 per 100 ml
101 - 500 " " "
501 - 1000 " " "
Over 1000 " " "
ELIZABETH RIVER
CRANEY I
NORFOLK
LAMBERT PT
Prepared by the U.S. PUBLIC HEALTH SERVICE

Unfortunately, the 1934 averages in the James River section and on the northeast portion of Willoughby Bank are based on a very small number of samples per point. As only two or three samples were taken at most of the points in these areas it is uncertain that the results shown were truly representative of average water quality. In the present survey at least 5 samples were taken at each point. When the five samples at a point were taken over various tide conditions and the results were reasonably consistent, it is believed that the averages shown are reasonably representative of conditions. As shown in Table 2 in Section VIII, a minimum of seven samples were taken at most points during the present survey.

With due attention to the considerations noted, comparison of the coliform density charts provides a valuable indication of any changes in water quality that have taken place in the intervening years. With the exception of one area between Newport News and Hilton Village, it will be noted that the pollution in the James River section shows a material decrease. In 1934 the water along the Newport News waterfront and extending to the west edge of the channel showed a considerable degree of pollution and this polluted area extended upstream on the west side of the channel beyond the present James River Bridge. On the east side of the river, the shore waters north of Newport News had an average coliform MPN under 100 per 100 ml. In 1949-50 the general level of pollution along the Newport News waterfront was markedly lower and did not extend as far toward the western shore. However, the zone with average MPN's ranging from 100 to 500 extended up the eastern bank of the river to a point nearly one and a half miles above Hilton Village and a zone of pollution with an average MPN in excess of 1,000 per 100 ml. was found near the Huntington Park-Ferguson Park septic tank outfall at the east end of the James River Bridge.

Comparison of Figures 11 and 12 show that there has been a very significant improvement in water quality in the Hampton Roads section since the time of the 1934 survey. In 1934 most of the Hampton Flats area had average coliform MPN's in excess of 100 per 100 ml. and in the vicinity of Newport News Point and along the entire shore line the averages were in excess of 500. At the time of the present survey the only area of the flats with an average MPN in excess of 500 was just off the mouth of Hampton Creek. In 1934 much of Craney Island Flats and the entire central section of the Roads had coliform densities in excess of 100 per 100 ml. and the Norfolk Harbor Channel north to Sewell Point had densities in excess of 1,000. In 1949-50 all of Craney Island Flats except a small strip immediately adjacent to Norfolk Harbor Channel had average coliform densities under 100 as did the central portion of the Roads. The average coliform MPN in the

Norfolk Harbor Channel area from Sewell Point south almost to the Lafayette River had declined from over 1,000 per 100 ml. to less than 500. The coliform MPN in the Fort Monroe area of Chesapeake Bay had declined from approximately 150 per 100 ml. to less than 50. The Willoughby Bank area showed an improvement although it was not as striking as in other areas.

B. Comparison with 1944 to 1949 Results

The State Department of Health made several surveys in portions of the area in the years 1944 to 1949. These surveys generally were not as intensive as the present survey. Fewer sample points were used and in several cases only one or two samples were taken at a given point. However, many of the sample points used were the same or closely adjacent to those used in the present survey and it is believed that comparison of the results of these surveys with those obtained in the present survey will give an indication of any changes in water quality that have occurred in recent years.

Table 4 presents the median coliform MPN per 100 ml. for all samples taken at each sample point during the various years together with the median results obtained on the present survey. In general, there has been a distinct improvement in the quality of the waters throughout the area but the improvement is least noticeable on Willoughby Bank. The results presented indicate that the bacterial quality of the waters on Hampton Flats has improved since the summer of 1949, particularly on the southwestern half of the area which is nearer to the outfall from the Boat Harbor Sewage Treatment Plant. This is believed to be due to more efficient chlorination of sewage which started about December 1.

TABLE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS - COMPARISON OF RESULTS

Coordinate Square	Median Coliform MPN per 100 ml.							
	1944	1945	1946	1945-46	1947	1948	1949 June-Aug.	1949-50 Oct.-Feb.
HAMPTON FLATS								
K-30	-	-	-	-	-	-	-	240
L-26	-	-	-	-	-	-	-	43
M-28	-	-	-	-	-	* 15	43	43
M-29	-	-	-	-	-	* 43	23	43
M-30	-	-	-	-	-	-	*460	43
N-26	-	-	-	-	-	-	-	23
N-29	-	-	-	-	-	-	*43	33
N-31	-	-	-	-	-	* 23	93	43
O-27	-	-	-	-	-	-	-	23
O-28	-	-	-	-	-	*240	43	-
O-29	-	-	-	-	-	-	-	23
O-30	-	-	-	-	-	-	-	23
O-32	-	-	-	-	-	-	*43	23
O-34	-	-	-	-	-	-	* 9.1	43
P-28	-	-	-	-	-	-	-	23
P-30	-	-	-	-	-	* 43	43	-
P-33	-	-	-	-	-	* 93	43	23
P-34	-	-	-	-	-	* 7.3	23	23
P-35	-	-	-	-	-	-	-	43
P-36	-	-	-	-	-	-	*16	-
Q-30	-	-	-	-	-	*240	93	23
Q-32	-	-	-	-	-	* 43	93	23
Q-36	-	-	-	-	-	* 23	23	23
Q-37	-	-	-	-	-	-	*29	23
R-32	-	-	-	-	-	-	-	21
R-33	-	-	-	-	-	* 23	23	23
R-34	-	-	-	-	-	* 43	43	23
R-37	-	-	-	-	-	* 23	23	23
R-38	-	-	-	-	-	-	*23	43
S-32	-	-	-	-	-	* 43	27	23

TABLE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS - COMPARISON OF RESULTS

Coordinate Square	Median Coliform MPN per 100 ml.						1949 June-Aug.	1949-50 Oct.-Feb.
	1944	1945	1946	1945-46	1947	1948		
				HAMPTON FLATS				
S-35	-	-	-	-	-	*93	75	23
S-38	-	-	-	-	-	*43	43	23
T-35	-	-	-	-	-	*93	43	23
T-36	-	-	-	-	-	*93	240	23
T-38	-	-	-	-	-	*93	150	23
T-40	-	-	-	-	-	-	-	43
U-37	-	-	-	-	-	*23	240	43
U-39	-	-	-	-	-	*240	240	43
U-40	-	-	-	-	-	*1100	93	-
V-35	-	-	-	-	-	*93	84	23
V-38	-	-	-	-	-	*93	93	-
V-41	-	-	-	-	-	*460	93	93
W-36	-	-	-	-	-	*240	272	23
W-38	-	-	-	-	-	-	-	43
W-39	-	-	-	-	-	*93	240	43
W-40	-	-	-	-	-	*240	93	23
X-36	-	-	-	-	-	-	-	23
X-42	-	-	-	-	-	*1100	75	43
X-43	-	-	-	-	-	-	*252	68
Y-40	-	-	-	-	-	-	-	43
Y-42	-	-	-	-	-	-	-	43
Y-43						*460	240	-
				NORFOLK HARBOR CHANNEL-ELIZABETH RIVER				
U-29	-	-	-	-	460	-	252	43
BB-29	-	-	-	-	+1100	*460	930	240
EE-29	-	-	-	-	+1100	*+1100	1020	93
JJ-29	-	-	-	-	+1100	*+1100	930	240
NN-29	-	-	-	-	+1100	-	2400	230
QQ-29	-	-	-	-	+1100	-	2400	460

TABLE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS - COMPARISON OF RESULTS

Coordinate	Median Coliform MPN per 100 ml.							
Square	1944	1945	1946	1945-46	1947	1948	1949 June-Aug.	1949-50 Oct.-Feb.
				CRANEY ISLAND FLATS				
DD-43	-	-	-	-	-	-	-	23
DD-45	-	93	270	-	-	-	-	23
EE-39	-	-	-	-	-	-	-	43
EE-41	-	43	195	-	-	-	-	23
EE-43	-	49	*460	-	-	-	-	-
EE-46	-	23	*240	-	-	-	-	-
FF-32	-	-	-	-	-	-	-	43
FF-35	-	-	-	-	-	-	-	23
FF-37	-	-	-	-	-	-	-	43
FF-39	-	93	180	-	-	-	-	-
FF-40	-	33	*460	-	-	-	-	-
GG-43	-	-	-	-	-	-	-	41
GG-45	-	-	-	-	-	-	-	23
GG-46	-	43	240	-	-	-	-	-
HH-32	-	-	-	-	-	-	-	45
HH-34	-	-	-	-	-	-	-	23
HH-37	-	-	-	-	-	-	-	23
HH-39	-	33	*23	-	-	-	-	23
HH-41	-	43	240	-	-	-	-	23
HH-46	-	43	166	-	-	-	-	15
II-35	-	-	-	-	-	-	-	23
II-37	-	-	-	-	-	-	-	23
II-39	-	-	-	-	-	-	-	23
II-41	-	-	-	-	-	-	-	9.1
II-43	-	-	-	-	-	-	-	23
II-44	-	80	*93	-	-	-	-	-
JJ-31	-	-	-	-	-	-	-	93
JJ-33	-	-	-	-	-	-	-	39
JJ-40	-	19	*23	-	-	-	-	-
JJ-42	-	43	*96	-	-	-	-	-
JJ-44	-	-	-	-	-	-	-	23

TABLE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS - COMPARISON OF RESULTS

Coordinate Square	Median Coliform MPN per 100 ml. 1944	1945	1946	1945-46	1947	1948	1949 June-Aug.	1949-50 Oct.-Feb.
				CRANEY ISLAND FLATS				
KK-37	-	-	-	-	-	-	-	23
KK-39	-	43	126	-	-	-	-	9.1
KK-41	-	-	-	-	-	-	-	9.1
KK-42	-	-	-	-	-	-	-	9.1
LL-30	-	-	-	-	-	-	-	150
LL-31	-	-	-	-	-	-	-	23
LL-33	-	-	-	-	-	-	-	23
LL-35	-	-	-	-	-	-	-	23
				FORT MONROE AREA				
F-16	-	-	23	-	-	-	-	-
F-21	-	-	9.1	-	-	-	-	-
G-20	-	-	-	-	-	-	-	9.1
I-21	-	-	-	-	-	-	-	9.1
K-18	-	-	93	-	-	-	-	-
K-21	-	-	-	-	-	-	-	16
K-22	-	-	43	-	-	-	-	-
L-22	-	-	-	-	-	-	-	16
N-22	-	-	-	-	-	-	-	19
N-23	-	-	290	-	-	-	-	-
				MOUTH OF ROADS				
N-25	-	-	-	-	240	350	240	43
P-25	-	-	-	-	240	460	195	43
R-24	-	-	-	-	272	240	93	93
T-24	-	-	-	-	-	-	-	43
U-24	-	-	-	-	-	-	-	93
V-24	-	-	-	-	240	240	93	210

TABLE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS - COMPARISON OF RESULTS

Coordinate Square	Median Coliform MPN per 100 ml. 1944	1945	1946	1945-46	1947	1948	1949 June-Aug.	1949-50 Oct.-Feb.
				WILLOUGHBY BANK				
N-16	-	-	-	93	-	-	-	-
O-12	-	-	-	93	-	-	-	-
O-14	*240	-	-	-	-	-	-	-
O-16	-	-	-	93	-	-	-	-
O-19	-	-	-	-	250	93	-	75
P-11	*23	-	-	-	-	-	-	-
P-13	*240	-	-	-	-	-	-	-
P-14	*150	-	-	*50	-	-	-	-
P-15	*62	-	-	-	-	-	-	-
Q-12	*86	-	-	-	-	-	-	-
Q-14	*68	-	-	-	-	-	-	-
Q-15	*106	-	-	-	-	-	-	-
R-9	-	-	-	23	-	-	-	-
R-12	*56	-	-	-	-	-	-	-
R-13	*150	-	-	43	-	34	9.1	23
R-14	-	-	-	-	-	68	39	29
R-15	-	-	-	93	-	33	23	31
R-16	*23	-	-	*23	-	43	23	16
R-17	*240	-	-	-	-	43	23	23
R-18	-	-	-	75	135	54	43	43
R-19	-	-	-	-	75	75	-	23
R-20	-	-	-	122	-	75	43	23
R-21	-	-	-	-	-	75	240	-
R-22	-	-	-	-	-	-	-	43
R-23	-	-	-	240	-	-	-	-
S-6	-	-	-	23	-	-	-	-
S-10	*240	-	-	-	-	-	-	-
S-11	*Indet.	-	-	-	-	-	-	-
S-13	*240	-	-	33	-	-	-	-
S-15	*23	-	-	-	-	-	-	-

TABLE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS - COMPARISON OF RESULTS

Coordinate Square	Median Coliform MPN per 100 ml.							
	1944	1945	1946	1945-46	1947	1948	1949 June-Aug.	1949-50 Oct.-Feb.
				WILLOUGHBY BANK				
S-16	-	-	-	-	-	68	23	33
S-17	-	-	-	33	-	58	43	43
S-18	-	-	-	-	-	23	23	43
S-19	-	-	-	-	-	93	93	43
S-20	-	-	-	-	-	33	240	43
S-21	-	-	-	-	405	240	240	43
T- 8	*1100	-	-	-	-	-	-	-
T-11	*23	-	-	-	-	-	-	-
T-12	*23	-	-	43	-	-	-	-
T-16	-	-	-	-	-	9.1	23	19
T-17	-	-	-	*39	93	33	39	43
T-18	-	-	-	-	-	48	23	43
T-19	-	-	-	-	-	43	93	43
T-20	-	-	-	-	-	43	43	43
T-21	-	-	-	-	-	120	43	68
U- 9	*460	-	-	-	-	-	-	-
U-10	-	-	-	19	-	-	-	-
U-15	-	-	-	68	-	-	-	-
U-16	-	-	-	-	-	-	-	9.1
U-17	-	-	-	93	93	93	43	-
U-18	-	-	-	-	-	-	-	23
U-19	-	-	-	93	-	242	93	23
U-20	-	-	-	-	-	460	93	-
U-21	-	-	-	-	-	-	93	-
V- 7	-	-	-	41	-	-	-	-
V- 8	*3.6	-	-	-	-	-	-	-
V-12	-	-	-	25	-	-	-	-
V-14	-	-	-	43	-	-	-	-
V-16	-	-	-	-	-	-	-	43
V-17	-	-	-	-	-	-	-	43

TABLE 4

SURVEY OF HAMPTON ROADS SHELLFISH AREAS - COMPARISON OF RESULTS

Coordinate	Median Coliform MPN per 100 ml.							
Square	1944	1945	1946	1945-46	1947	1948	1949 June-Aug.	1949-50 Oct.-Feb.
				WILLOUGHBY BANK				
W-15	-	-	-	-	-	-	-	15
X-10	*93	-	-	23	-	-	-	-
Y- 8	*93	-	-	-	-	-	-	-
Y-11	-	-	-	23	-	-	-	-
Y-14	-	-	-	-	-	-	-	23
Z- 6	*14	-	-	-	-	-	-	-
Z-12	-	-	-	33	-	-	-	-

* Less than 3 samples.

+ Indeterminate, but greater than value shown.

X

SEWAGE CHLORINATION AT PLANTS

A. Methods

The three sewage treatment plants of the Hampton Roads Sanitation District and the treatment plant of the City of Portsmouth were designed for primary treatment plus chlorination of the effluent. Two of the plants (the Army Base Plant of the Hampton Roads Sanitation District and the Portsmouth Plant) were provided with chlorine contact tanks. At the other two plants chlorine contact tanks were not provided and the theoretical flow-time in the underwater outfall was relied upon to provide the proper chlorine contact period. At all plants provision was made for introducing the chlorine solution from the manual control vacuum chlorinators into the settling tank effluent (post-chlorination) or into the raw sewage flow ahead of the settling tank (pre-chlorination).

In September, 1949, prior to the period of the survey, the Army Base and Boat Harbor Plants of the Hampton Roads Sanitation District were using rechlorination, applying about one third of the chlorine ahead of the settling tanks and two thirds to the settled sewage. These two plants were applying chlorine at an average dosage of 18 and 16 ppm respectively. The Army Base Plant was apparently obtaining satisfactory chlorination as judged from the reported minimum and average residuals for each day. Chlorination at the Boat Harbor Plant was far from satisfactory as it reported 24 days with a minimum residual of zero and 5 days with a minimum residual of 0.05 ppm, and on 24 days the recorded residuals averaged less than 0.20 ppm. At this plant, chlorinator capacity was inadequate to apply sufficient chlorine to the strong midday flows to obtain a residual, a condition which was not corrected until December 1. At the Lambert Point Plant, chlorine was applied at an average dosage of 21 ppm to the settling tank effluent, but every day one or more of the recorded residuals was 0 ppm.

The operating personnel of the Hampton Roads Sanitation District believed that adequate mixing of the chlorine with the effluent was not being obtained in the outfall sewers at the Boat Harbor and Lambert Point Plants where there were no contact tanks. They also thought that better control of chlorine residual could be maintained by applying the chlorine ahead of the settling tanks. This was tried first at Boat Harbor Plant, where the chlorine was applied to the pump discharge line prior to the grit chamber and Parshall flume.

The Lambert Point Plant changed to prechlorination a short time later. Army Base Plant changed from re- to pre-chlorination on December 2.

The Pinner Point Plant in Portsmouth used post-chlorination until January 25. Chlorine application averaged 20 ppm in November, 16 ppm in December and 21 ppm in January and much of the time there was no residual at the outlet of the chlorine contact tank. In February with pre-chlorination, the chlorine applied averaged 25 ppm with more than 50 per cent of the residuals recorded as zero. The sewage arriving at the Portsmouth plant apparently was more stale than that received at the plants of the Hampton Roads Sanitation District, probably due to long detention in the suction wells and wet wells of the pumping stations, and undoubtedly had a greater chlorine demand. A comparison of the raw sewage pH at the Portsmouth plant with that at the Boat Harbor and Lambert Point Plants as shown in Table 5 below would indicate a greater septicity in the Portsmouth sewage:

TABLE 5 - RAW SEWAGE pH AT TREATMENT PLANTS

	Portsmouth			Boat Harbor			Lambert Point		
Month	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Dec.	7.00	5.95	6.75	7.52	6.64	7.10	7.32	6.86	7.14
Jan.	7.10	6.80	6.95	7.42	6.69	7.10	7.57	6.91	7.15
Feb.	6.90	6.30	6.69	7.21	6.89	7.08	7.32	6.70	7.08

B. Controls Used During Survey

At the time the survey was started there were no records of the bacterial quality of the sewage treatment plant effluents. Ortho-tolidine chlorine residual determinations were made hourly and the average and minimum residuals for each day were noted in plant reports.

During the latter part of October, morning and afternoon grab samples were taken of the influent sewage at the Boat Harbor Plant for coliform MPN determinations. The bacteriological determinations were made in the laboratory of this survey. The coliform MPN per 100 ml. of the raw sewage varied from a minimum of 7,500,000 to a maximum of 240,000,000 with a median of 43,000,000. Similar grab samples were taken of the chlorinated effluent, using thiosulfate to dechlorinate the sample. In general, three samples were taken in the early morning hours and three in the afternoon to represent the periods of weak and strong sewage flow. The coliform MPN per 100 ml. of these effluent samples varied from a minimum of less than 30,000 obtained on an 8:00 AM sample to a maximum of 110,000,000 obtained at 8:00 PM. The median was 4,600,000.

In November arrangements were made with the Hampton Roads Sanitation District Commission to have bacteriological samples of the effluent taken at each of their plants at 2:00 AM, 4:00 AM and 6:00 AM and at 10:00 AM, 12:00 Noon and 2:00 PM. These samples were to be composited in the laboratory into two samples to be known as "Minimum Flow" and "Maximum Flow." Bacteriological determinations of the samples from the Army Base Plant and the Lamberts Point Plant were made in the laboratory of the Sanitation District at the Lamberts Point Plant and the determinations of the samples from the Boat Harbor Plant were made in the laboratory of this survey. These samples were taken daily at the Army Base and Lamberts Point Plants and five days a week at the Boat Harbor Plant. Ortho-tolidine chlorine residuals were taken at the same time and place as the bacteriological samples and were recorded individually. Similar arrangements were made at the Portsmouth plant for bacteriological samples of the effluent to be taken two days a week, the bacteriological determinations to be made at the laboratory of the City Health Department.

The basic control of sewage chlorination for the purpose of maintaining low coliform densities in the receiving waters must be the coliform MPN of the effluent. However, for practical purposes of plant operation, the plant operator must necessarily rely on the maintenance of an effluent chlorine residual that will indicate adequate chlorination to ensure a satisfactory effluent, but without excessive use of chlorine. It was hoped that the combination of bacteriological and residual controls used would enable the determination of such a chlorine residual for each of the plants concerned.

C. Efficiency of Chlorination

Data concerning chlorine application, chlorine residuals and effluent coliform MPN for the various plants are given in Table 6. Due to changes in amounts of chlorine used and in the point of application, the results are given by months for each plant.

TABLE 6 - SEWAGE CHLORINATION AT TREATMENT PLANTS

	Nov. (Nov.20-30)	Dec.	Jan.	Feb. (1-17)
HAMPTON ROADS SANITATION DISTRICT				
BOAT HARBOR PLANT				
No. of chlorine residuals reported	24	117	107	64
No. of composite effluent samples	8	39	38	25
Avg. Flow - MGD	7.9	8.43	8.0	6.5
Avg. Chlorine Applied-ppm	21.3	26.4	25.1	22.
Chlorine Residuals				
% less than 0.1 ppm	71	3	14	25
% Composite Samples with minimum residual less than 0.1 ppm	75	10	9	40
Coliform MPN per 100 ml. (composite sample)				
Maximum	4,300,000	23,000	+110,000	+1,100,000
Minimum	300	-30	-30	-30
Median	1,615,000	-30	-30	930
% over 1,000	75	10	24	40
% over 10,000	50	3	11	28
% over 20,000	50	3	5	20
% over 50,000	50	0	5	12
LAMBERT POINT PLANT				
No. of chlorine residuals reported	42	149	129	78
No. of composite effluent samples	14	50	43	26
Avg. Flow - MGD	13.9	13.4	11.7	10.9
Avg.Chlorine Applied-ppm	21.7	20.2	20.2	22.1
Chlorine Residuals				
% less than 0.1 ppm	2	11	8	8
% Composite Samples with minimum residual less than 0.1 ppm	2	26	21	23

TABLE 6 - SEWAGE CHLORINATION AT TREATMENT PLANTS

	Nov. (Nov.20-30)	Dec.	Jan.	Feb. (1-17)
HAMPTON ROADS SANITATION DISTRICT				
LAMBERT POINT PLANT (Cont'd)				
Coliform MPN per 100 ml. (composite sample)				
Maximum	+1,100,000	+1,100,000	15,000	+110,000
Minimum	-30	-30	-30	-30
Median	82	230	150	330
% over 1,000	21	36	16	27
% over 10,000	14	32	5	19
% over 20,000	14	32	0	12
% over 50,000	7	14	0	8
ARMY BASE PLANT				
No. of chlorine residuals reported	41	146	129	78
No. of composite effluent samples	14	49	44	26
Avg. Flow - MGD	6.7	6.4	6.5	6.7
Avg. Chlorine Applied-ppm	17.8	18.1	16.1	17.4
Chlorine Residuals				
% less than 0.1 ppm	0	5	14	3
% Composite Samples with minimum residual less than 0.1 ppm	0	10	20	8
Coliform MPN per 100 ml. (composite sample)				
Maximum	11,000	+1,100,000	240,000,000	+110,000
Minimum	-30	-30	-30	-30
Median	100	2,400	930	310
% over 1,000	29	61	45	23
% over 10,000	7	35	23	4
% over 20,000	0	35	20	4
% over 50,000	0	14	18	4

TABLE 6 - SEWAGE CHLORINATION AT TREATMENT PLANTS

	Nov. (Nov.20-30)	Dec.	Jan.	Feb. (1-17)
PORTSMOUTH				
PINNER POINT PLANT				
No. of chlorine residuals reported	-	186	185	138
No. of composite effluent samples	-	10	20	8
Avg. Flow - MGD	-	6.3	6.2	5.8
Avg. Chlorine Applied-ppm	-	15.6	21.0	24.5
Chlorine Residuals				
% less than 0.1 ppm	-	51	71	82
% composite samples with minimum residual less than 0.1 ppm	-	70	100	100
Coliform MPN per 100 ml. (composite sample)				
Maximum	-	+1,100,000	+1,100,000	11,000,000
Minimum	-	110,000	210,000	11,000,000
Median	-	+1,100,000	+1,100,000	11,000,000
% over 1,000	-	100	100	100
% over 10,000	-	100	100	100
% over 20,000	-	100	100	100
% over 50,000	-	100	100	100

Note: All chlorine applied ahead of settling tanks except as noted below:

Army Base Plant Nov.21 to 28 incl. applied 72% of chlorine as postchlorination between settling tank and chlorine contact tank.

Portsmouth-Pinner Point Plant applied all chlorine between settling tank and chlorine contact tank until Jan. 25.

Boat Harbor Plant. Prechlorination discontinued Feb.14 because of sludge settling troubles.

A "Composite Sample" is a composite of equal volumes of three individual samples taken at 2 hour intervals at time of daily high flow or low flow. Ortho-tolidine chlorine residuals were taken at same time and point as individual bacteriological samples and recorded as separate values. A "minimum residual" for a composite sample is the lowest residual recorded for the composite period.

It will be noted that at Boat Harbor Plant in November, before sufficient chlorinator capacity was available, 75 per cent of the samples had minimum residuals less than 0.1 ppm and that the coliform MPN of the effluent was very high. In December and January more adequate chlorination was maintained and a very low percentage of the effluent samples had an MPN in excess of 20,000. The rate of chlorine application at this plant was considerably greater than at the other plants of the Hampton Roads Sanitation District and efforts were made to reduce the chlorine usage without adverse effect on the effluent. The results indicate that the saving in chlorine amounted to 160 pounds per day which, at the quoted cost of $65.00 per ton, would cost $5.25. This saving, however, is reflected in the poorer quality of the effluent with 20 per cent of the samples having a MPN in excess of 20,000 per 100 ml. With the close proximity of the Hampton Flats oyster beds to the outfall from this plant, it is questionable whether this minor saving is justified.

The results from the Army Base plant are difficult to interpret. This plant has a chlorine contact tank and in November was using rechlorination with 72 per cent of the total chlorine applied at the inlet to the contact tank. Adequate residuals were maintained and the coliform density of the effluent was low with no samples having an MPN in excess of 20,000 per 100 ml. In December, with pre-chlorination, most of the residuals were at least 0.1 ppm, but the bacterial quality of the effluent was poor. In January, the average chlorine dosage was lower than in December, more of the samples had a minimum residual of less than 0.1 ppm, but the bacterial quality of the effluent was improved. In February, chlorine dosage was slightly increased and chlorine residuals and effluent quality were both satisfactory.

It is evident that the Portsmouth plant did not succeed in obtaining satisfactory chlorination during the period of the survey, although chlorine dosages were constantly increased until in February the average dosage was 24.5 ppm. Only three of the chlorine residuals reported exceeded 0.1 ppm. As previously noted, the sewage arriving at the Portsmouth plant is very stale and on many occasions is strongly septic and black in color. Upsewer chlorination for control of septicity was to be installed and it was hoped that this would solve the difficulty.

In order to determine what would constitute a satisfactory level of chlorination at the plants of the Hampton Roads Sanitation District, Table 7 was prepared showing the coliform MPN results obtained at various levels of chlorination. Results for the three plants are given separately. All samples are composites of three individual samples taken at two hour intervals. Only results obtained when the chlorine was applied ahead of the primary settling tank are included. The level of chlorination is based upon the minimum residual reported for the sample period rather than on the average residual.

It is noticeable that the apparent efficiency of chlorination varied greatly from plant to plant. The results obtained at any level of minimum residual were much better at Boat Harbor Plant than at Lamberts Point. A possible reason for this is that, due to factors of design capacity and actual flow, the detention period in the settling tanks is much longer at Boat Harbor Plant than is normal for primary sedimentation.

TABLE 7

HAMPTON ROADS SANITATION DISTRICT PLANTS
SEWAGE CHLORINATION HAMPTON ROADS SANITATION DISTRICT PLANTS
EFFLUENT COLIFORM MPN PER 100 ML.
DEC. 1, 1949 - FEB. 17, 1950
PRE-CHLORINATION ONLY

	BOAT HARBOR	LAMBERT POINT	ARMY BASE	ALL PLANTS
EFFLUENT MINIMUM CHLORINE RESIDUAL LESS THAN 0.1 PPM				
No. of samples	23	28	14	65
Maximum MPN	+1,100,000	+1,100,000	240,000,000	240,000,000
Minimum MPN	-30	-30	430	-30
Median MPN	91	2,400	460,000	2,400
Per cent of samples with:				
MPN over 1,000	39	57	86	57
MPN over 10,000	30	39	64	42
MPN over 20,000	22	32	64	35
MPN over 50,000	13	21	64	28
EFFLUENT MINIMUM CHLORINE RESIDUAL 0.1 PPM OR MORE				
No. of samples	73	91	101	265
Maximum MPN	+11,000	46,000	1,100,000	1,100,000
Minimum MPN	-30	-30	-30	-30
Median MPN	-30	230	930	150
Per cent of samples with:				
MPN over 1,000	14	18	41	25
MPN over 10,000	3	13	17	12
MPN over 20,000	0	7	14	8
MPN over 50,000	0	0	5	2
EFFLUENT MINIMUM CHLORINE RESIDUAL 0.2 PPM OR MORE				
No. of samples	50	77	88	215
Maximum MPN	4,600	46,000	1,100,000	1,100,000
Minimum MPN	-30	-30	-30	-30
Median MPN	-30	120	590	91

TABLE 7 (Cont'd)

	BOAT HARBOR	LAMBERT POINT	ARMY BASE	ALL PLANTS
EFFLUENT MINIMUM CHLORINE RESIDUAL 0.2 PPM OR MORE				
Per cent of samples with:				
MPN over 1,000	6	14	39	22
MPN over 10,000	0	12	14	10
MPN over 20,000	0	7	13	7
MPN over 50,000	0	0	5	2
EFFLUENT MINIMUM CHLORINE RESIDUAL 0.3 PPM OR MORE				
No. of samples	18	63	73	154
Maximum MPN	2,300	46,000	1,100,000	1,100,000
Minimum MPN	-30	-30	-30	-30
Median MPN	-30	91	430	36
Per cent of samples with:				
MPN over 1,000	6	13	36	23
MPN over 10,000	0	9	15	11
MPN over 20,000	0	5	15	9
MPN over 50,000	0	0	5	3

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D. Effect of Adequate Chlorination on the Receiving Waters

As shown in Subsection C, the chlorination obtained at the Boat Harbor Plant was very inadequate prior to December 1. Any continuing gross bacterial pollution in the effluent from this plant would be reflected in the water quality on Hampton Flats.

Figures 13 and 14 show the median coliform densities in the waters of the Hampton Roads section of the survey before and after December 1, respectively. A comparison of the two figures clearly shows the difference in water quality when an incompletely chlorinated effluent with a median coliform MPN in excess of 1,000,000 per 100 ml. is discharged and when the effluent is completely chlorinated and has a median MPN of less than 30.

It will be noted that after December 1 the waters of the Elizabeth River-Norfolk Harbor Channel showed an improvement in quality, although there was no significant change in the water quality of the Lafayette River except near the mouth where results would be influenced by water carried upstream on flood tides. It is considered probable that this improved quality may be attributable to increased attention to chlorination control at the sewage treatment plants.

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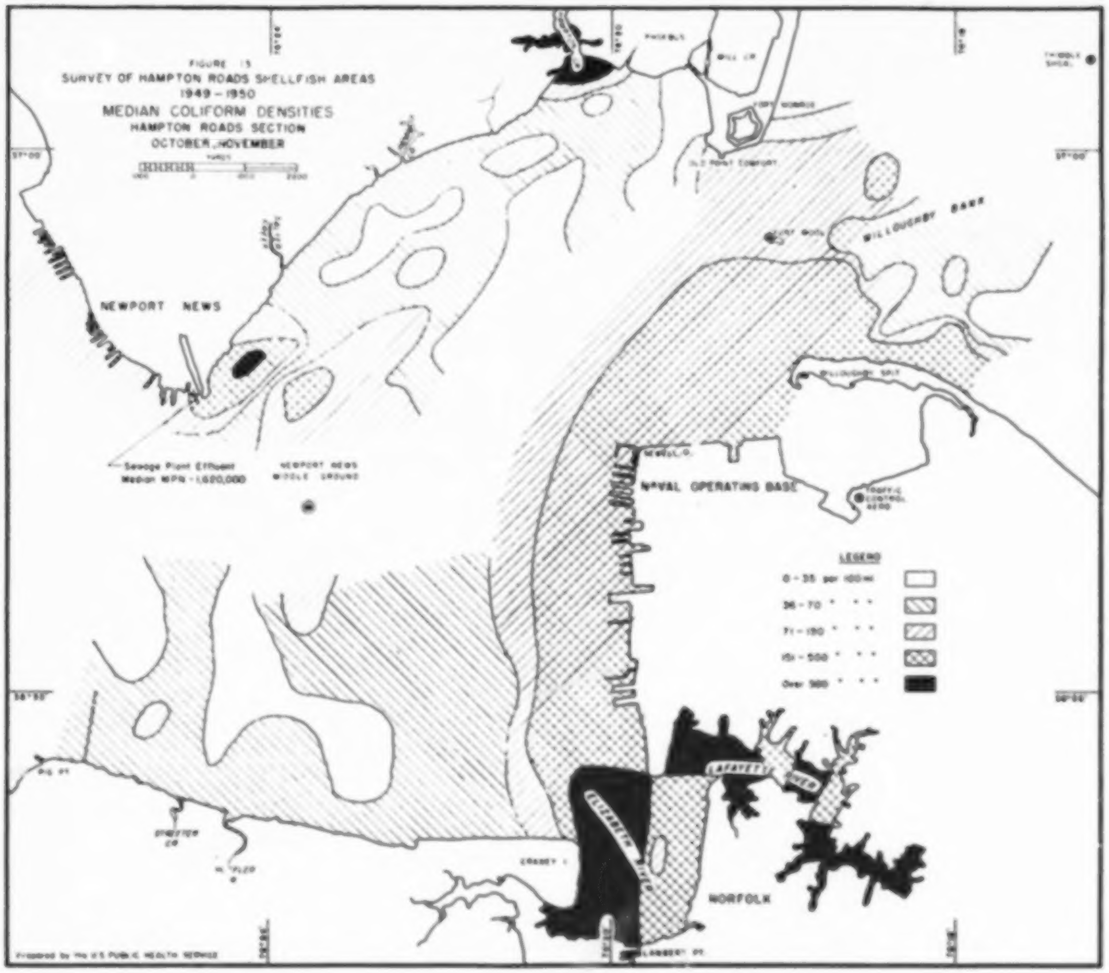

FIGURE 15
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 – 1950
MEDIAN COLIFORM DENSITIES
HAMPTON ROADS SECTION
OCTOBER, NOVEMBER

YARDS
1000 0 1000 2000
37°00'
NEWPORT NEWS
Sewage Plant Effluent
Median MPN - 1,620,000
NEWPORT NEWS
MIDDLE GROUND
PHOEBUS
MILL CR.
FORT MONROE
OLD POINT COMFORT
THIMBLE SHOAL
FORT WOOL
WILLOUGHBY BANK
WILLOUGHBY SPIT
NAVAL OPERATING BASE
TRAFFIC CONTROL AREA
LEGEND
0 - 35 per 100 ml
36 - 70 " " "
71 - 150 " " "
151 - 500 " " "
Over 500 " " "
36°55'
PIG PT.
LAFAYETTE RIVER
ELIZABETH RIVER
CRANEY I.
NORFOLK
LAMBERTS PT.
Prepared by the U.S. PUBLIC HEALTH SERVICE

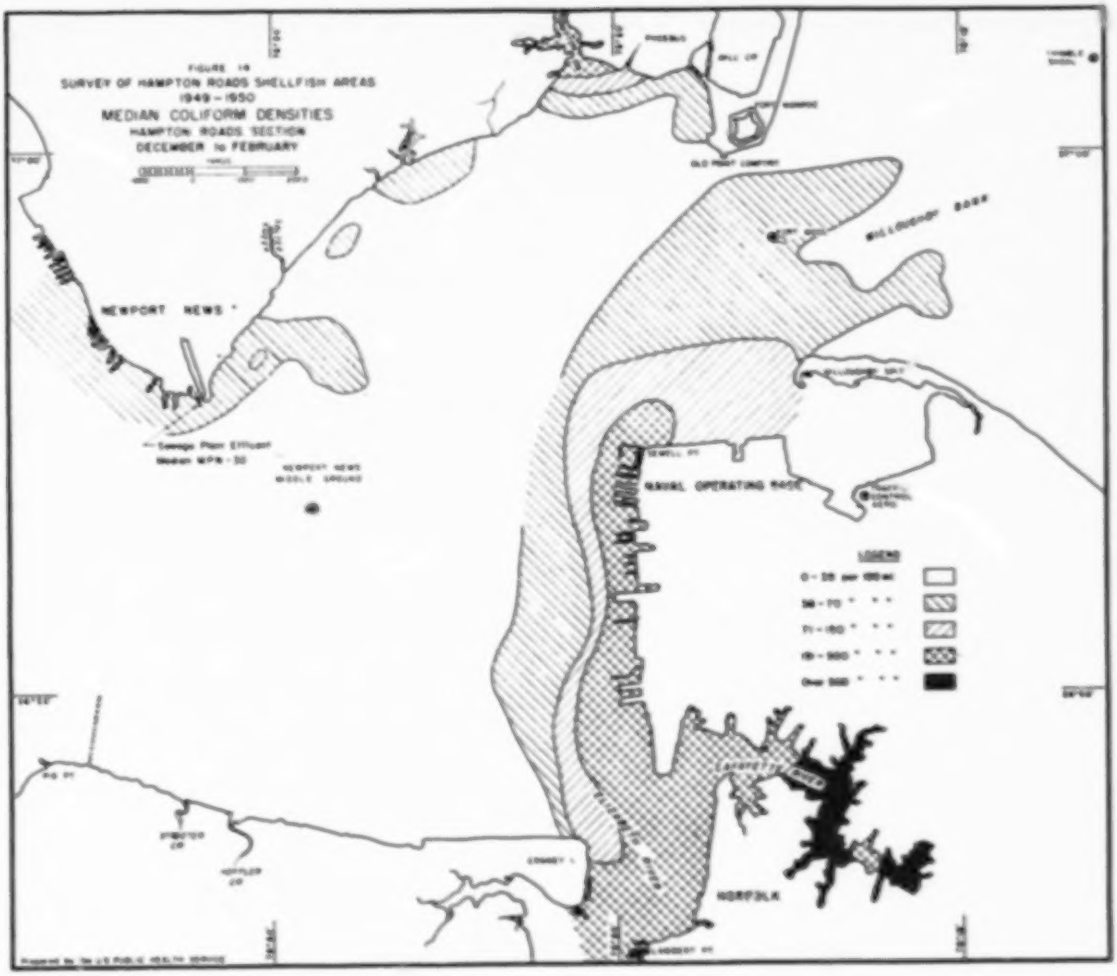
FIGURE 14
SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949 - 1950
MEDIAN COLIFORM DENSITIES
HAMPTON ROADS SECTION
DECEMBER to FEBRUARY
PHOEBUS
MILL CR
FORT MONROE
OLD POINT COMFORT
WILLOUGHBY BANK
NEWPORT NEWS
← Sewage Plant Effluent
Median MPN - 30
NEWPORT NEWS
MIDDLE GROUND
WILLOUGHBY SPIT
SEWELL PT
NAVAL OPERATING BASE
NORFOLK
LEGEND
0 - 30 per 100 ml
31 - 70 " " "
71 - 150 " " "
151 - 500 " " "
Over 500 " " "
PIG PT
CRANEY I.
Prepared by the U.S. PUBLIC HEALTH SERVICE

E. Chlorination Objectives

In consideration of the proximity of the Boat Harbor Plant outfall to the important shellfish growing area of Hampton Flats and the results obtained during January and February, it would seem desirable to maintain an effluent that would have a coliform MPN per 100 ml. under 10,000 for not less than 90 per cent of the time and an MPN under 20,000 for 95 per cent of the time. Apparently this can be attained at this plant with prechlorination if not more than 10 per cent of the hourly chlorine residuals are less than 0.1 ppm. It is believed that the chlorination program should be aimed to maintain a residual of 0.2 ppm with no residuals to be less than 0.1 ppm. Reference to Table 7 indicates that if all residuals are 0.1 ppm or more, it may be expected that the effluent from this plant will have a coliform MPN less than 10,000 per 100 ml. more than 90 per cent of the time.

The Lamberts Point, Army Base and Pinners Point Plants are not in as close proximity to major shellfish growing areas as is the Boat Harbor Plant. At present there is a greater amount of raw sewage discharged to tidal waters in this area than there is on the northern shore. In consideration of these factors, it is believed that if the effluent MPN at these plants does not exceed 20,000 per 100 ml. more than 20 per cent of the time, the present water quality conditions will be maintained. This effluent quality apparently can be met by the same program of chlorination as is recommended for the Boat Harbor Plant. When the remaining raw sewage discharges have been diverted to the treatment plants and if some method is developed to eliminate overboard discharge from vessels tied up to docks, a review of this recommendation may be in order.

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XI

RECOMMENDATIONS

The results obtained during this survey show that there has been a decided improvement in the bacteriological quality of the waters overlying the shellfish beds of the Hampton Roads area since the intercepting sewer systems and sewage treatment plants were placed in operation. The results show that if chlorination at Boat Harbor Plant is continued as in December and January and the other sewage treatment plants chlorinate as efficiently as did the Lambert Point Plant during the same two months, the bacterial quality of the water on Craney Island Flats, Willoughby Bank and most of Hampton Flats will be within the limit prescribed for harvesting oysters for direct marketing. However, due to tidal currents and proximity to existing or potential discharges of pollutional material, certain portions of these areas should not be opened to shellfish harvesting.

In consideration of these facts, it is recommended that consideration be given to allowing the taking of market oysters from the following areas:

1. Hampton Flats. The central portion of these flats within the following boundaries referred to navigation and other markers and true bearings as shown on U. S. Coast and Geodetic Survey Chart 400 of Hampton Roads: Starting at a point 450 yards from and north 65 degrees east of the Watch House located opposite Cedar Avenue and east of the mouth of Salters Creek, thence in a northeasterly direction (approximately 65 degrees) for a distance of 3,750 yards to a point 900 yards offshore on a line from the mouth of the small creek east of La Salle Avenue (and midway between Indian River and Hampton Creek) to Light "16A" (Occ R ev 3 sec.), thence southeasterly (approximately 133 degrees) 1,450 yards in the direction of Light "16A", thence northeasterly (approximately 65 degrees) to the center of Old Point Comfort dock, thence southwesterly (approximately 223 degrees) to Bell "2" (FLR), thence northwesterly (approximately 305 degrees) 1,500 yards to a point midway between Spars "20N" and "22N", thence northwesterly to point of beginning.

2. Craney Island Flats. That portion east of the present restriction line (which is from Middle Ground Light to a point on shore 800 yards east of Hoffler Creek) to a line from a point on shore 1,500 yards west of the northeast corner of Craney Island to the mouth of the small creek east of LaSalle Avenue in Elizabeth City County and south of the 18 foot depth contour on the south side of the deep water channel.

3. Willoughby Bank. That portion west of the present restriction line (which is from "Traffic Control-Aero" to Thimble Shoals Light) and north of a line from a point on the present restriction line 1,000 yards off Willoughby Spit to Old Point Comfort dock.

Removal of existing restrictions in these areas is necessarily contingent upon compliance with certain requirements. These include assurance that the present raw sewage discharges will be eliminated in accordance with a reasonable program of performance to ensure that there shall be no future deterioration of water quality; the continued attainment of satisfactory standards of bacterial quality of sewage plant effluents together with the establishment of adequate controls of sewage treatment; and the establishment of adequate safeguards against treatment interruptions and breakdowns. Procedures should be set up for immediate reporting to the State Department of Health of any interruption of plant operation (causing by-passing of sewage) or any interruption of satisfactory chlorination.

Parameters of potentially hazardous interruptions of sewage treatment must be established. Similar parameters of potentially hazardous concentration of naval vessels in Naval Anchorage B and in Explosives Anchorage F-1 must be established. Requirements must be established for immediate reporting of all interested parties of the closing of the affected areas when these parameters are exceeded.

These potential hazards from sewage treatment interruption and shipping are further discussed in Section XII. It is desirable that supplemental studies be made to determine the effects on the waters of Hampton Flats of sewage discharges from naval vessels at anchor in Anchorages B and F-1. It is suggested that the Hampton Roads Sanitation District Commission might undertake such studies in cooperation with the Fifth Naval District as supplementary to the bacteriological records of treatment plant operation. Similar studies of the effect on adjacent waters should be made immediately following the inadvertent discharge of any large quantity of untreated sewage from the Boat Harbor Plant or its tributary pumping stations.

To ensure a satisfactory sewage treatment plant effluent it is recommended that a standard of bacterial quality for the effluent of the Boat Harbor Plant be stated as having a median coliform MPN, in any one month, not in excess of 500 per 100 ml., based on not less than 16 composite samples per month, and that not more than 10 per cent of the samples shall have an MPN in excess of 10,000 per 100 ml. Determinations of the chlorine residual of the effluent should be made hourly and recorded in the permanent plant records. These records of chlorine residual should be correlated with bacterial quality of the effluent as determined from frequent composite samples to determine the maximum per cent of residuals less than 0.1 ppm that may be allowed and still ensure a satisfactory effluent. On the basis of results obtained during this survey it would appear that when the chlorine is applied ahead of the settling tanks and not more than 10 percent of the hourly residual readings are less than 0.1 ppm, the effluent should be within the limits recommended.

To maintain a bacterial quality of the waters of the Norfolk Harbor Channel and Willoughby Bank equal to that found during December and January, it is recommended that a standard of quality for the effluent of the other sewage treatment plants be stated as having a median coliform MPN, in any month, not in excess of 1,000 per 100 ml. based on not less than 16 composite samples per month, and that not more than 20 per cent of these samples shall have a coliform MPN in excess of 20,000 per 100 ml. Hourly chlorine residual readings should be taken and recorded as recommended for the Boat Harbor Plant. It is believed that if not more than 10 per cent of these hourly residual readings are less than 0.1 ppm, with the chlorine applied ahead of the settling tanks, that this effluent standard will be met. It is recognized that during December and January the results of chlorination at the Portsmouth plant did not meet this standard. However, it is believed that by use of upsewer chlorination to prevent septicization of the sewage before it reaches the treatment plant that this standard can and should be met at the Portsmouth plant as well as at the plants of the Hampton Roads Sanitation District.

In order to maintain an accurate record of possible sewage overflows due to any failure of pumping stations, it is recommended that recording water level gauges be installed in the wet wells of every pumping station that has an emergency overflow. If the necessary equipment could be installed so that the operator at the treatment plant could make frequent checks by telephone of the water level in the various wet wells, it would aid in early discovery and correction of any operating difficulty. The minimum precaution that should be approved is the daily inspection of each pumping station by a competent maintenance crew to detect and remedy any failure in equipment that might be the cause of an overflow.

Proper control of sewage chlorination where it is essential to maintain a very low coliform MPN in the effluent at all times apparently requires precautionary measures not normally considered.

It is believed that reliance should not be placed on computed detention in an outfall to provide the needed contact period, but that an adequate contact tank should be provided. With a long outfall serving as a contact chamber, either submerged or flowing partially full, it is impractical or impossible to collect frequent samples of the effluent for chlorine residual readings and bacteriological determinations and reliance must be placed on results from samples taken at the entrance to the outfall and held for a predetermined period. The contact tank should have a true retention period (as determined by a dye test) of 30 minutes based on anticipated daily maximum dry weather flow. If the contact tank is properly baffled with around the end baffles to prevent short circuiting of part of the flow, this true retention period will more closely approach the theoretical, or computed, detention period. It also is considered necessary for the chlorine solution to be completely and quickly mixed with the entire sewage flow. If the chlorine is to be introduced into the settling tank effluent just ahead of the contact tank, this could be accomplished by means of a flash mixer similar to that used for mixing chemical solutions or suspensions with water in a water treatment plant.

It is essential that means be provided for altering the rate of chlorine feed promptly with changes in flow quantities and chlorine demand. This requires frequent residual readings to be made closer to the point of chlorine application than a 30 minute flow period. It is suggested that such a control point be established at a point about 15 minutes flow from the point of chlorine application and that residual readings at this point be made every half hour. This control reading is not to be substituted for the hourly effluent reading which is the actual record of effluent conditions. If a small pump were to be installed, taking its suction from this control point and discharging a constant flow to a sink adjacent to the chlorinator room, it would facilitate the taking of frequent samples for chlorination control.

When a satisfactory chlorine residual recorder is developed for settled sewage, similar to that now available for water chlorination, it should be installed at each plant to make a continuing written record of the chlorine residual of the effluent, not for purpose of chlorine control, but to provide a record for the use of the State Department of Health in judging the adequacy of chlorination. Such an instrument is not presently available and reliance must be placed on recorded hourly readings of the effluent chlorine residual.

XII

POSSIBLE HAZARDS REQUIRING FUTURE INVESTIGATIONS

It is believed that adherence to the recommendations given in the previous section will make it possible to release a large acreage of shellfish growing areas from the restrictions that have been applied in the past. It is recognized that certain potential hazards still exist, but the determination of their probable influence on local conditions and the possibility of their elimination will require further investigation and study that was not possible at the time of this survey. These hazards are readily classified in three categories: (1) ship-borne pollution; (2) polluted storm water overflows; (3) raw sewage discharges due to failure of plant. A correlative problem is the period that an area should remain closed under an emergency restriction after the temporary source of pollution has been abated.

1. It is believed that ship-borne pollution, particularly from naval vessels with their large crews, presents the most serious hazard to the oyster growing areas. Merchant shipping does not present a serious problem because the ships dock as rapidly as possible and do not usually tie up for long periods in the anchorages. Furthermore, the anchorages used by commercial craft (with the exception of the quarantine anchorage in the main channel near the northeast end of Hampton Flats where vessels remain only a few hours at most) are not in close proximity to the shellfish beds. There are no passenger liners or cruise ships with large crews that have Hampton Roads for a terminus. The commercial ships found in Hampton Roads are tankers, colliers and general cargo ships with crews averaging about 50 men and when they are at dock only a minimum of the crew remain on board.

Naval ships with their large crews present a more serious problem. The piers at the Naval Operating Base are frequently crowded with ships. No provision is made on the vessels for discharge of sewage to land sewers when the ship is at dock. Therefore, there will generally be a population of approximately 5,000 to 10,000 discharging raw sewage into the Norfolk Harbor Channel at its northern end, even after all sewers are connected to the treatment plants. The effects of this discharge will probably be detectable as far as the western portion of Willoughby Bank.

There is a naval anchorage just east of the central portion of Hampton Flats. If this anchorage should be occupied by a large concentration of naval vessels, particularly large ships with crews in excess of 500 men, it is possible that flood tides would carry this pollution over Hampton Flats in sufficient quantities to require that the harvesting of market oysters be prohibited. During the period of this survey this anchorage at times held six or seven ships for a period of one or two days, but they were vessels of the fleet service train or small combat ships and no effect of sewage discharge was detected at the sample points on Hampton Flats. No direct evidence was obtained during this survey to indicate what would constitute a major concentration of naval vessels in this anchorage that would constitute a hazard to the shellfish beds on Hampton Flats. However, it is considered that any concentration of combat ships in Anchorage B (See U.S.Coast and Geological Survey Chart 400) in excess of the following would constitute a major concentration that might be considered hazardous to these shellfish beds:

1. Any combat ships moored less than 800 feet from the edge of the flats and less than 1,600 feet apart.
2. Any combat ships with crews in excess of 1,200 each moored less than 1,600 feet from the edge of the flats and less than 3,300 feet apart along the line of the channel.
3. More than one combat ship with crew in excess of 1,600 with no such ship to be moored less than 3,000 feet from the edge of the flats.
4. Any concentration of ships with combined crews in excess of 3,000.

It is emphasized that studies should be made to determine the permissible limits of floating population for this anchorage. Such studies were proposed in Section XI of this report.

2. In general, there are no storm water overflows from combined sewers in the Hampton Roads area except those at the Naval Operating Base. Due to tide gates at the outfalls and the variations in tidal level, it would be impracticable to install liquid level gauges to tell when overflows occur. No record of operation of these overflows is presently available. Maintenance of the sewer system within the Naval Operating Base, including the diversion chambers on these overflows, is under jurisdiction of the officials of the base. It would be preferable that a maintenance crew of the Hampton Roads Sanitation District inspect these diver-

sion chambers daily and clean them as necessary. Due to the apparent direction of travel of pollution in the Norfolk Harbor Channel, overflows from these combined sewers would probably have more effect on the waters over the west end of Willoughby Bank than on those over Craney Island Flats. The western portion of Willoughby Bank, at sample point T-21, is distant 2-1/2 miles from these overflows.

3. Probably the most persistent hazard to the maintenance of satisfactory bacterial quality in the waters of Hampton Roads is the possibility of the discharge of inadequately chlorinated sewage occasioned by plant failure at either the treatment plants or the pumping stations. The possibility of frequent routine checks of pumping station operation has been mentioned in Section XI. Pumping stations should be designed with sufficient pump capacity so that if any one pump becomes inoperative for any reason, standby pumps with sufficient capacity to handle any flow that can reach the station will automatically cut in. Sufficient chlorinator capacity should be installed at treatment plants and maintained in operating condition so that in case of failure of any one chlorinator there will still be capacity available to satisfy 110 per cent of the maximum demand anticipated.

On at least one occasion during the period of the survey, one of the pumping stations was out of service for several hours because of electric power failure. The major pumping stations should be supplied power from two independent main circuits with arrangements for automatic changeover in case of failure on the circuit in use.

Plant operation records show that the Lambert Point Plant was out of operation for two periods totalling 3.08 hours on November 24 and for a period of 1.0 hours on December 4 because of electric power failure. The Army Base Plant was out of operation for 2.92 hours on November 24 for the same cause. To avoid such interruptions in plant operation, a standby source of power should be available at each plant. Such standby power could be provided by dual fuel engines to operate on either fuel oil or digestor gas. These engines should be operated frequently enough to assure their immediate availability in case of need.

No definite statement is possible at this time as to the amount of raw sewage overflow that would constitute sufficient hazard to make closing of adjacent shellfish areas advisable. Practically no opportunity was offered during the period of this survey to attempt the determination of the effect of an intermittent discharge of raw sewage on the quality of adjacent waters. However, results obtained on two occasions on which known cases of overflow were followed by sampling of the adjacent waters on the following day may be of assistance in arriving at conclusions concerning this problem for the two particular areas involved.

The Lambert Point Plant outfall discharges about half way between the shoreline and the Elizabeth River channel in Coordinate Square QQ-27. On December 4, between 11:25 AM and 12:25 PM, an estimated 470,000 gallons of untreated sewage was discharged here because of power failure. Samples were taken in the Norfolk Harbor-Elizabeth River Channel the following day on ebb tide about 22 hours following the cessation of raw sewage discharge with the results noted below:

Sample Point	Distance from Outfall-yards	Coliform MPN per 100 ml.	
		Dec. 5	Median Ebb Tide
EE-29	7000 N	93	150
JJ-29	3500 N	1100	240
NN-29	1400 NW	240	93
QQ-28	700 SW	930	930

The overflow from the Claremont Pumping Station in Elizabeth City County discharges to the waters of Hampton Flats in Coordinate Square N-34. On December 5 between 2:00 AM and 8:00 AM an estimated 500,000 gallons of raw sewage was discharged at this point. Samples were taken at points within a radius of 2,000 yards on ebb tide about 11:00 AM on December 6 and 7, 27 hours and 51 hours, respectively, after cessation of the discharge, with the following results:

Sample Point	Distance from Outfall-yards	Coliform MPN per 100 ml.		
		Dec. 6	Dec. 7	Median Ebb Tide
O-34	500 S	93	9.1	43
P-33	800 SE	43	23	33
O-32	1100 SE	150	3.6	23
P-34	1100 S	43	23	23
Q-32	1500 SE	15	23	43
O-30	200 SE	15	43	23

APPENDIX I

Sample and Laboratory Forms

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SURVEY OF SHELLFISH AREAS

Bottle No. 84
Sample Point Q-32 Area Hampton Flats Weather Clear Wind: Dir. ______ Vel. ______
Date 12/15/49 Sample collector R. W Lab. No. 1478
Time Collected 0916 Tide Cycle Ebb Tim- — Bact. A. W
Type sample Water Time sample planted 1150

COLIFORMS

Portion planted	Lactose		BGBLB		Tubes conf.
	24 hr.	48 hr.	24 hr.	48 hr.	
10	+		+		3
	—	+	+		
	+		+		
1	—	—			0
	—	—			
	—	+	—	—	
1/10	—	—			0
	—	—			
	—	—			

Water temp. 6
Air temp. 2
Salinity-hydrometer ______ Grm/100 mls ______
pH ______
Remarks:
Coliform MPN 23

INDIVIDUAL SAMPLE - LABORATORY CARD

Sample Point JJ-31

Survey of Hampton Roads Shellfish Areas
1949-1950

Sheet 1 of 2

Date	Lab. Sample No.	Coliform M.P.N. per 100 ml.	Physical Data										
			Time collect	Water		Wind		Tide		Weather			Remarks
				Temp. deg.C.	Salin. deg.	Dir.	Est.vel. m.p.h.	Hours	Phase	24 hr. precip inches	Exist. weath.	Air temp.	
1949													
Oct 31	340	>1100	1113	19	8	WSW	13		Ebb	0.26	Cloudy	22	
Nov 2	412	240	1030	16	7.5	S	9		Ebb	2.82	Cloudy	19	
9	576	93	1019	14	7	W	5.8		Flood	0	Clear	16	
15	683	75	1029	15	7	NW	6		Ebb	0	Clear	14	
28	913	430	1120	9	9	NE	7.4		Flood	0	Cloudy	13	
30	1008	43	1244	11	8.5	W	6		Flood	0.12	Clear	14	
Dec 7	1243	150	1445	9.5	8	SW	10		Ebb	0	Cloudy	13	
21	1642	240	1228	8	9	SW	5.8		Ebb	0	Cloudy	12	
27	1707	23	1112	10	9	S	9.5		Flood	T	Cloudy	14	
28	1745	23	1037	10	9	E	9.1		Flood	0.51	Clear	15	
1950 Jan 3	1945	93	1259	9	9	S	11.8		Ebb	0	Cloudy	15	
5	2039	240	1158	10	9	SW	10.4		Ebb	0	Clear	17	
11	2181	43	1036	10	9	NW	9.5		Flood	T	Cloudy	14	
17	2347	43	1200	10	9	NE	8.5		Ebb	0.01	Cloudy		
24	2540	9.1	1209	9	9	SW	10.1		Flood	0	Cloudy		

APPENDIX II

Sample Course Directions

Sample Point Descriptions

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SAMPLE COURSE DIRECTIONS

ELIZABETH RIVER - CRANEY ISLAND

(27 Sample Points)

Sample Point Number	Description (All bearings magnetic)
	ELIZABETH RIVER
U-29	At Gong "1" (FLW) NNW of Sewall Point
	Head south along Norfolk Harbor Channel
Z-29	At Light Buoy "3" (FLG) (black buoy)
	Head for inner scaffold light N of Sewall Point (FLG ev 10 sec)
X-28	On range of end of north pier (NOB) and Light Buoy "7" (FLW) (black buoy)
	Return to Norfolk Harbor Channel and head south
BB-29	At Light Buoy "7" (FLW) (black buoy) off Ferry Dock and south of Pier 2 at NOB
EE-29	At Spar 2 (red) at south side of entrance to slip south of Pier A
JJ-29	At Can "13" southeast of Pier No. 1
NN-29	At Light Buoy "17" (FLW) (black buoy and second light buoy south of Can 13) east of Craney Island Light
QQ-28	At Can "21" (black) northwest of N&W coal pier
	CRANEY ISLAND
	Head north to Nun "14" (red) north of Craney Island
LL-30	At Nun "14"

Sample Point Number	Description (All bearings magnetic)
	Head for Watch House off Hoffler Creek (stern bearings Nun 14 and Marine Hospital Tank
LL-31	On range of cupola on army chapel and left radio tower. Just before range of Light Buoy "17" and single stack
LL-33	On range of left end of riprap seawall and small square building on mound, and on range of Light Buoy "17" (black) and twin yellow stacks on incinerator (Norfolk)
LL-35	On range of small white building in center of low area of shore and center of rough stone riprap seawall
KK-37	Just after getting "wrecks" abeam. On range of small pine to right of large pine and center of A roof on single story white building
KK-39	On range of leaning pine tree and dip in line of tree tops.
	Head for Spar "79N" and "obstruction" off north shore (bearing approx. 15 deg.)
II-39	Near 2 small pole stakes on line with oyster spars inshore. On range White Spar C and tank at inshore end Pier No. 1.
	Head for Can 13 (100 deg.)
II-37	On range of riprap jetty and left end of group of trees (elms) to right of low area of shore
II-35	On range of "wreck" and small square building on mound
JJ-33	On range of cupola of army chapel and left radio tower and on range of Light Buoy "11"

Sample Point Number	Description (All bearings magnetic)
	(black) and white house south (right) of oil tanks near Army Base
JJ-31	On range of end of Craney Island and outer end of N&W coal pier. Also on range of Elizabeth River Light Buoy "11" (black) and checkered elevated tank on Sewall Point
	Head for Spar "74N" (330 deg.) (stern bears on Spar "81N" south of Nun 14)
HH-32	On range of radio tower and end of N&W coal pier
	Head for Spar "80N" and Spar "78N" (280 deg.)
HH-34	At spar "80N" (marked S10N)
HH-37	On range of 3rd oil tank from left on Craney Island and end of N&W coal pier Also on range of Middle Ground Light and large elevated tank in Newport News
HH-39	On range of end of C&O coal pier (Newport News) and south tower James River Bridge lift span. Also on range of army chapel (Craney Island) and large crane at Navy Yard (Portsmouth)
	Head for midpoint between Newport News Channel Light Buoy "6" (FLR) and White Spar "M" (approx. 0 deg.) (or 6 deg. or 4 plus fingers to left of Middle Ground Light)
EE-39	On range of White Spar "E" and Middle Ground Light and Hampton Flats Watch House. Also on range of end of C&O coal pier and lift span on bridge
	Head for Spar "75N" (100 deg.)
FF-37	On range of Middle Ground Light and center of group of high trees on north shore

Sample Point Number	Description (All bearings Magnetic)
FF-35	On range of Middle Ground Light and elevator of C&O coal pier (Newport News)
FF-32	At Spar "75N" (marked 11N)

END OF SAMPLE COURSE

SAMPLE POINT DESCRIPTIONS

NOTE: All bearings magnetic
Navigation markers and prominent shore marks from Coast and Geodetic Survey East Coast-Virginia-Charts 400, 452 and 529.

FORT MONROE

G-20	500 yards offshore on range of cupola on large brick building and 4th tower from south on small arms range
I-21	500 yards offshore by outer end of old piling at north end of concrete seawall. Phoebus water tank is hidden behind gray steel building
K-21	500 yards offshore on range of wood water tank on tower (painted green) and outer end of old piling. Thimble Shoal Light bears 100 deg. Phoebus Tank bears 280 deg.
L-22	500 yards offshore just north of range of East and West Tanks at Fort Monroe. Thimble Shoal Light bears 90 deg. Phoebus Tank bears 293 deg.
N-22	500 yards offshore on range of Phoebus Tank and east Tank at Fort Monroe. On range of Old Point Comfort Light and southeast corner of Chamberlin Hotel. Fort Wool Light about midway between Grain Elevator and Clock Tower (Norfolk)
O-19	On range of Phoebus Tank and East Tank at Fort Monroe On range Fort Wool Light and Thimble Shoal Light. Chimney north of Chamberlin Hotel halfway between hotel and Old Point Comfort Light. Thimble Shoal Light bears 68 deg. Fort Wool Light bears 248 deg.

MOUTH OF ROADS

N-25	At Can 1 southwest of Chamberlin Hotel
P-25	On course from Can 1 to Bell "2" (FLR) and on line of center of Fort Wool and Light "6" at entrance to Hampton Creek. Light should be one finger to left of right hand stack of group of stacks. Fort Wool Light bears 135 deg. Old Point Comfort Light bears 35 deg.

MOUTH OF ROADS -(Cont'd)

R-24	At Bell "2" (FLR)
T-24	At Light Buoy "5" (FLW)
U-24	On course from Light Buoy "5" to Light Buoy "6" (FLR) and on range of last building on Willoughby Spit and checkered water tank near Naval Operating Base airfield.
V-24	At Light Buoy "6" (FLR)

LAFAYETTE RIVER

KK-22	Just west of Can 9
KK-23	Approximately 400 yards east of Hampton Blvd. bridge
KK-24	Approximately 200 yards west of Hampton Blvd. bridge
KK-25	In channel between Light "7" and Nun 8
LL-26	In channel between Light "3" and Nun 4 in mouth of Lafayette River
MM-21	At Nun 12
NN-21	At Nun 14
NN-27	At Light "2" (red) at entrance to Lafayette River channel
OO-20	At Nun 16

ELIZABETH RIVER (including Norfolk Harbor Channel)

U-29	At Gong "1" NNW of Sewall Point
X-28	On line from Light Buoy "3" (FLG) to inner scaffold light north of Naval Operating Base (FLG ev 10 sec) and on range outer end of north quay at Naval Operating Base and Light Buoy "7" (FLW)
X-29	At Light Buoy "3" (FLG)

ELIZABETH RIVER (including Norfolk Harbor Channel) (Cont'd)

BB-29	At Light Buoy "7" (FLW) off Ferry Dock and south of Pier 2, Naval Operating Base.
EE-29	At Spar 2 (red) at southside of entrance to slip south of Pier A
JJ-29	At Can 13 southwest of Pier No. 1
NN-29	At Light Buoy "17" (FLW) (second light buoy south of Can 13) east of Craney Island Light
QQ-28	At Can 21 northwest of N&W coal dock
TT-28	At Light Buoy "23" (FLG) (Black Buoy)
TT-28A	At Nun 24 (red)
UU-27	At red and black nun approximately midway between Nun 24 and Nun 26
VV-26	At Nun 26 north of Portsmouth sewage treatment plant

CRANEY ISLAND FLATS

DD-43	At Spar "83N" (marked 83N)
EE-39	On range of White Spar "E", Middle Ground Light and Hampton Flats Watch House. Also on range of end of C&O coal pier in Newport News and lift span on James River Bridge
EE-41	At Black and White Can
FF-32	At Spar "75N" (marked 11N) off grain elevator (Norfolk)
FF-35	On course 280 deg. from Spar "75N" and on range of Middle Ground Light and elevator at C&O coal pier (Newport News)
FF-37	On course 280 deg. from Spar "75N" and on range of Middle Ground Light and center of group of high trees on shore (north shore)
GG-43	Stack and Elevated Tank at Army Base (east of Piers 1 and

CRANEY ISLAND FLATS (Cont'd)

GG-43	2) bear 100 deg. On range of Middle Ground Light and Phoebus Tank and just west of range of unnumbered Black and White Can and Middle Ground Light
GG-45	On range of Nansemond River Light and Can 1 and Nun 2 of Pig Point channel and on range of Middle Ground Light and Chamberlin Hotel
HH-32	Stack and tank east of Piers 1 and 2 bear 100 deg. On range of radio tower on Craney Island and end of N&W coal pier (Lambert Point)
HH-34	At Spar "8ON" (marked S 10 N)
HH-37	On range of 3rd oil tank from east on Craney Island and end of N&W coal pier and on range of Middle Ground Light and large elevated tank in Newport News. Stack and tank at Army Base bear 100 deg.
HH-39	On range of end of C&O coal pier (Newport News) and south tower of James River Bridge lift span and on range of army chapel (Craney Island) and large crane at Navy Yard (Portsmouth)
HH-41	Stack and tank at Army Base bear 100 deg. On range of Watch House and radio tower on south shore
HH-46	At end of old Pig Point wharf (off twin elevated tanks)
II-35	Can 13 (Elizabeth River Channel) bears 100 deg. End of Pig Point Wharf bears 280 deg. On range of "wreck" with small square building on mound
II-37	End of Pig Point Wharf bears 280 deg. Riprap jetty lines with east end of group of trees (elms) to west of low area of shore.
II-39	Near 2 small pole stakes on line with oyster spars inshore and half mile west of II-37
II-41	End of Pig Point Wharf bears 280 deg. On range of C&O coal pier elevator and large gas tank at Newport News

CRANEY ISLAND FLATS (cont'd)

II-43	End of Pig Point Wharf bears 280 deg. On range of Watch House and silo on shore
JJ-31	On range of northeast corner of Craney Island and outer end of N&W coal pier and on range of Elizabeth River Light Buoy "11" (black) and checkered elevated tank at Sewall Point
JJ-33	On range of cupola of army chapel and left radio tower and on range of Elizabeth River Light Buoy "11" and white house south of oil tanks near Army Base
JJ-44	On range of Phoebus Water Tank and Middle Ground Light and on range of observation tower and dip in tree line on south shore
KK-37	Elevated tank at Marine Hospital (Norfolk) bears 105 deg. Just west of "wrecks". Small pine to west of large pine on south shore on range with center of A roof on single story white building
KK-39	Marine Hospital tank bears 105 deg. Watch House off Hoeffler Creek bears 285 deg. On range of leaning pine on shore and dip in line of tree tops
KK-41	Watch House bears 285 deg. Off Hoeffler Creek between silo and large white house between trees
KK-42	At Watch House
LL-30	At Nun "14" (Elizabeth River)
LL-31	On range of Lafayette River Light "3" and Marine Hospital Tank and on range of army chapel cupola and left radio tower
LL-33	On range of east end of riprap seawall and small square building on mound and on range of Elizabeth River Light Buoy "17" (black) and twin yellow stacks on incinerator (Norfolk)
LL-35	Marine Hospital Tank bears 100 deg. On range of small white building in center of low area of shore and center of riprap seawall

WILLOUGHBY BANK

R-13	At Spar "57N" (marked 27N) south of Thimble Shoal Light
R-14	Thimble Shoal Light bears 20 deg. Airport Water Tank bears 207 deg. On range of checkered water tank near Naval Operating Base airfield (Airport Water Tank) and house just to right of gap in buildings. East Tank at Fort Monroe one finger (approx. 2 deg.) to left of Phoebus Tank
R-15	Thimble Shoal Light bears 30 deg. Airport Water Tank bears 200 deg. Spar "57N" bears 95 deg. On range of cupola of Nansemond Hotel (Ocean View) and dip in line of tree tops. East Tank at Fort Monroe one-half finger to left of Phoebus Tank.
R-16	Spar "56N" bears 275 deg. Thimble Shoal Light bears 37 deg. On range of East Tank at Fort Monroe and Phoebus Tank.
R-17	Spar "56N" bears 275 deg. Thimble Shoal Light bears 45 deg. On range of last house on Willoughby Spit and north end of multistory concrete building at Naval Operating Base on Sewall Point
R-18	At Spar "56N" (marked 26N)
R-19	Spar "56N" bears 95 deg. Thimble Shoal Light bears 53 deg. On range of East Tank at Fort Monroe and right end of gray steel storage shed.
R-20	Norfolk Harbor Channel Bell Buoy "2" bears 275 deg. Thimble Shoal Light bears 60 deg. Airport Water Tank bears 145 deg. On range of last house on Willoughby Spit and Clock Tower (Naval Operating Base). Porch with white columns (Gen. Clark's quarters at Fort Monroe) is just to left of right hand stack of group of 3 stacks
R-22	Norfolk Harbor Channel Bell Buoy "2" (red) bears 275 deg. Airport Water Tank bears 157 deg. Old Point Comfort Light bears 340 deg. On range of east end of Fort Wool and Hampton Creek Light "6"

WILLOUGHBY BANK (cont'd)

S-16 Grain elevator bears 250 deg. Airport Water Tank bears 197 deg. Chamberlin Hotel bears 303 deg. On range of East Tank at Fort Monroe and low gray building. Phoebus Tank just to right of West Tank at Fort Monroe

S-17 Grain Elevator bears 230 deg. Fort Wool Light bears 288 deg. Airport Water Tank bears 190 deg. On range of East Tank at Fort Monroe and left end of gray building and on range of last building on Willoughby Spit and left penthouses of multistory concrete building at Naval Operating Base.

S-18 Chamberlin Hotel bears 310 deg. Grain elevator bears 225 deg. Airport Water Tank bears 180 deg. Sewall Point Tank is slightly to right of end of Willoughby Spit

S-19 Sewall Point Tank bears 240 deg. Airport Tank bears 175 deg. On range of Phoebus Tank and West Tank at Fort Monroe

S-20 Old Point Comfort Light bears 325 deg. Fort Wool Light bears 300 deg. Grain Elevator bears 220 deg. On range of Clock Tower and point of Willoughby Spit (Willoughby Spit Light)

S-21 Old Point Comfort Light bears 338 deg. Grain Elevator bears 215 deg. On range of Grain Elevator and Clock Tower and on range of point of Willoughby Spit and stack to left of high water tank (bearing 208 deg.) On range of West Tank at Fort Monroe and right end of double white building on waterfront

T-16 Thimble Shoal Light bears 30 deg. Cupola of Nansemond Hotel bears 165 deg. Airport Tank bears 197 deg.

T-17 Thimble Shoal Light bears 35 deg. Airport Tank bears 190 deg. Just east of range of Grain Elevator and tank south east of Clock Tower. On line of oyster spars

T-18 Thimble Shoal Light bears 40 deg. Airport Tank bears 180 deg. On range of Phoebus Tank and West Tank at Fort Monroe

WILLOUGHBY BANK (cont'd)

T-19 Thimble Shoal Light bears 45 deg. Airport Tank bears 175 deg. On range of Old Point Comfort Light and white tower on building. Sewall Point Tank is slightly to right of last building on Willoughby Spit

T-20 Thimble Shoal Light bears 50 deg. Airport Tank bears 165 deg. On range of Old Point Comfort Light and West Tank at Fort Monroe. End of Willoughby Spit is one finger (approx. 2 deg.) to left of group of tanks at Naval Operating Base

T-21 Thimble Shoal Light bears 55 deg. Airport Tank bears 155 deg. Norfolk Harbor Channel Light Buoy "5" (FLR) bears 280 deg. On range of Chamberlin Hotel and center of Fort Wool. Willoughby Spit Light is four fingers (approx. 7 deg.) to left of high tank south of Grain Elevator

U-16 Cupola of Nansemond Hotel bears 157 deg. Airport Tank bears 197 deg. Sewall Point Tank bears 255 deg. Fort Wool Light bears 302 deg.

U-18 Approx. 500 yards offshore. On range of Old Point Comfort Light and West Tank at Fort Monroe and on range of Grain Elevator and tank. Off white brick house with end chimney and long roof slope to west

U-19 Approx. 500 yards offshore. On range of right corner of building on Old Point Comfort Wharf and left corner of Chamberlin Hotel. At double net stand stakes on range of brush pole and Thimble Shoal Light and approximately off two-story house with overhanging second floor porch on east side

V-16 Approx. 500 yards offshore off brick two story house with upper and lower porches at 7th View Ave. Airport Tank bears 197 deg. Cupola of Nansemond Hotel bears 147 deg. Sewall Point Tank bears 260 deg.

V-17 Approx. 500 yards offshore. Thimble Shoal Light bears 35 deg. Airport Tank bears 185 deg. On range of Old Point Comfort Light and Phoebus Tank. Airport Tank is four fingers (approx. 7 deg.) to left of white building with arched windows

WILLOUGHBY BANK (cont'd)

W-15	Approx. 500 yards offshore. On line of 3rd View Ave. (northwest of park). On range of Airport Tank and space between white house and large brown, shingled house.
Y-14	On line from Thimble Shoal Light to cupola of Nansemond Hotel. Approx. 250 yards offshore and on range of northwest wall of hotel

JAMES RIVER

C-63	Approx. 1000 yards offshore at head of fishnet abeam of white brick house with white chimney. James River Light Buoys "9" (FLW) and "10" (FLR) bear 280 deg.
D-61	Approx. 1000 yards offshore. On line from abandoned White Shoal Light (piling) and white brick house with white chimney. (Taken between piles and duck blind)
F-58	Approx. 1000 yards offshore on line from "Monument" to James River Bell Buoy "6" (FLR)
H-56	Approx. 1000 yards offshore on line from "Monument" to fixed span of James River Bridge
H-57	On north side of Watch House ("Platform")
H-62	At James River red Nun 8 between Lake Maury and White Shoal
I-54	About 1000 yards offshore on range of Hilton Village Tank and summerhouse on seawall in front of red brick house with steps down bank
J-53	Approx. 1000 yards offshore on range of Hilton Village school and Hilton Village Tank and on range of north end of James River Bridge and first tank south of bridge.
J-55	On line from Watch House to second tank south of James River Bridge and on range of Hilton Village Tank and summerhouse on seawall in front of red brick house with steps down slope

JAMES RIVER (cont'd)

J-58	On line from third span northeast of lift span of James River Bridge to Bell "6" (FLR) and on range of "Monument" and Watch House
J-59	At Bell "6"
K-51	Near end of wood pier just north of northeast end of James River Bridge
K-56	On line from third span northeast of lift span of James River Bridge to Bell "6" and on range of Hilton Village Tank and summerhouse on top of green turfed bank
K-65	Just east of Nun 2 in Pagan River entrance
L-54	On line from third span northeast of lift span of James River Bridge to Bell "6" and on range of Hilton Village Tank and house with white gable on southeast end
M-53	On upriver side of bridge at center of third span northeast of lift span
M-63	On range of red Nun 8 (James River) and Bell "1PC" in James River south of White Shoal
O-50	On line from first tank south of James River Bridge to Can 3 (black) and on line from south tower of lift span to north tank in shipyard (about halfway between fishnets and 900 yards northwest of northwest corner of shipyard)
O-61	On range of Watch House and Morrison Water Tank and on range of fixed span and red tank in shipyard
P-57	On range of southwest end of steel girder spans south of lift span and first tank south of bridge and on range of center of fixed span and red tank in shipyard
S-49	Approx. 500 yards off pier head line on range of end of No. 1 pier in shipyard and red tank
S-54	On range of lift span of James River Bridge and Hilton Tank and on range of Can 3 and Spar "85N". (Near inshore end of 2nd line of net stakes south of bridge)

JAMES RIVER (cont'd)

W-47	Approx. 400 yards off end of main C&O coal wharf (FR lights)
W-51	On range of radio tower and large square coal elevator and on range of Can 1 and large C&O coal dock. Also on range of Can 3 and Nansemond River Light off Pig Point
Z-50	On range of Can 1 and red tank in shipyard. On line from James River bridge to twin elevated tanks on Pig Point and also on line from C&O coal pier to Light Buoy 3 in Batten Bay.
DD-45	On range of end of C&O coal pier and tank on Virginia Ave. at north end of shipyard and on range of radio tower at Boat Harbor and Dodge Plant stack (brick). Also on range of black and white can off Nansemond River and twin elevated tanks on Pig Point

HAMPTON FLATS AND NORTH SHORE INLETS

K-25	Center of concrete pile highway bridge (State Route 239) over Mill Creek (east bridge)
K-26	Center of timber pile highway bridge (U.S. Route 60) over Mill Creek (west bridge)
K-30	At mouth of Hampton Creek in center of channel
L-26	At Mill Creek Channel Nun 10 (red)
M-28	Between Can 3 (black) and Nun 4 (red) of Hampton Creek channel
M-29	On south side of Hampton Creek Light "6" (FLR ev 4 sec)
M-30	Just north of Can 1 (black) (southwest of Hampton Creek Light "6")
N-26	100 yards north of Hampton Creek Channel Light Buoy "1A" (FLW) (west of Chamberlin Hotel at Old Point Comfort)
N-29	At Spar "72N" (south of Hampton Creek Light "6")

HAMPTON FLATS AND NORTH SHORE INLETS (cont'd)

N-31	On line from Watch House to outlet from Mill Creek and on approx. range of Spar 72N and Hampton Creek Nun 4. Pile cluster bears 330 deg.
N-33	At mouth of unnamed creek east of La Salle Ave. (State Route 167) and southwest of Hampton Creek
O-27	At Main Channel Nun 14 (red)
O-29	On line from radio tower at Small Boat Harbor to Hampton Creek Channel Can 3-Nun 4 and on line from Main Channel Nun 14 to pile cluster near shore. On approx. range of Hampton Creek Can 5 (black) and Spar 72N
O-30	Red Light "16A" (Occ R ev 3 sec) bears 160 deg. On line from "obstruction" (northwest of Watch House) to stack north of Chamberlin Hotel. On line from pile cluster to Main Channel Nun 16. Just west of range of Nun 16 and Light "16A". On range of Light "16A" and tank at Naval Operating Base to right (S.S.E.) of clock tower
O-32	At stake approx. 700 yards offshore and on range of Spar 71 N and Main Channel Nun 18. On line from mouth of creek near La Salle Ave. (Sample N-33) to Main Channel Nun 16
O-34	At "diving board". Cupola one block west of La Salle Ave. bears 20 deg. About 500 yards offshore. Approximately on line from Watch House to mouth of creek near La Salle Ave.
O-36	At Chesapeake Boulevard bridge over Indian Creek
O-37	At mouth (between brick factory and old barge) of small creek near Hastings Instrument Co.
P-28	At light (FLR ev 5 sec) west of Main Channel Nun 14
P-33	On line from Watch House to Mill Creek outlet. On line from cupola to Spar 71N. Cupola bears 330 deg. Taken at buoy stake

HAMPTON FLATS AND NORTH SHORE INLETS (cont'd)

P-34	On line from Watch House to Mill Creek outlet and on line from Nun 2 to mouth of Indian Creek. Taken at stake and spar
P-35	Approximately 500 yards off mouth of Indian Creek
Q-30	At Main Channel Nun 16 (red)
Q-32	Slightly east of range of Gong 1 and clock tower (Naval Operating Base). On range of Spar 71N and Nun 18. Approximately on line from Nun 18 to mouth of creek east of LaSalle Ave. (State Route 167). Red Light "16A" bears 100 deg.
Q-36	On line from Watch House to Mill Creek outlet and on line from "obstruction" to Nun 2 (red)
Q-37	About 500 yards offshore and 200 yards north of "obstruction"
R-32	At Spar 71N
R-34	On line from Radio Tower at Small Boat Harbor to Hampton Creek Channel Can 3 - Nun 4 and a little west of range of Main Channel Nun 18 and Nun 2. At Oyster Spar "D" on range of Nun 2 and clock tower at Naval Operating Base. Nun 2 bears 125 deg.
R-37	On line from Watch House to Mill Creek outlet. At stake off wharf. On line from end of old wharf to Main Channel Nun 18
R-38	Just off old wharf
S-32	At Main Channel Nun 18
S-35	On line from Radio Tower to Hampton Creek Channel Can 3-Nun 4 and on range of "obstruction" and brick house with white window frames
S-38	Just southeast of Watch House
S-40	At Chesapeake Boulevard bridge over Salters Creek

HAMPTON FLATS AND NORTH SHORE INLETS (cont'd)

T-35	On line from Radio Tower to Main Channel Nun 18 and on range of Watch House and left corner of hospital
T-36	On line from White Spar "B" (main channel) to cupola just northeast of brick hospital (northeast of Salters Creek) On line from Spar 70N to end of old wharf. Watch House bears 295 deg.
T-38	On line from Radio Tower to Hampton Creek Can 3-Nun 4 On line from Main Channel Light Buoy "4" (FLR) to end of old wharf. On range of Watch House and second white house right of hospital.
T-40	On line from Ferry Channel Bell "2" at Newport News Point to Watch House. On line from Newport News Channel Light Buoy "5" (FLW) to mouth of Salters Creek.
U-37	On line from Main Channel Nun 18 to Radio Tower and on range of Newport News Channel Light Buoys "3" (FLW) and "4" (FLR). On range of Watch House and red brick house to right of hospital. At oyster spar buoy "Q" near leader of fishnet
U-39	On line from cupola northeast of Salters Creek to Newport News Channel Light Buoy "5" (FLW) and on line from Radio Tower to Hampton Creek Channel Can 3-Nun 4. On range of steel stack and water tank. Red brick house with dormer windows bears 310 deg. Taken at spar buoy and stake.
V-35	At Spar "70N" (almost submerged) On line from Spar 73N to Main Channel Nun 18 and on line from end of old wharf (Sample R-38) to Main Channel Bell "2" (FLR)
V-41	On line from Ferry Channel Bell "2" to Watch House and approximately on line from Newport News Channel Light Buoy "4" (FLR) to inshore end of wharf ruins. About 400 yards northeast of outer end of wharf ruins
W-36	At Spar "73N"

HAMPTON FLATS AND NORTH SHORE INLETS (cont'd)

W-38	On line from end of wharf (Sample R-38) to Spar "77N" southeast of Middle Ground Light and on line from center of wharf ruins to Spar 73N. On line from Main Channel Light Buoy "4" (FLR) to brick house with 3 dormer windows. Approximately on range of Light Buoy "4" and Grain Elevator (Norfolk)
W-39	On line from Newport News Channel Light Buoy "4" (FLR) to outer end of wharf ruins. On line from cupola northeast of Salters Creek to Middle Ground Light. Taken between Light Buoy "6" and oyster spar (nearer to spar)
W-40	On line from Hampton Creek Channel Can 3-Nun 4 to Radio Tower. On range of Newport News Channel Light Buoy "6" (FLR) and Middle Ground Light. On line from Dodge Plant Stack (brick) to Light Buoy "5" (FLW) (black buoy)
X-36	At Newport News Channel Light Buoy "4" (FLR) (red buoy)
X-42	Just northwest of Ferry Channel Bell "2" at Newport News
X-43	Off east bulkhead line of slip west of sewage treatment plant and Small Boat Harbor (Newport News Creek) On line from Newport News Light Buoy "8" (FLR) to end of coal pier
Y-40	At Newport News Channel Light Buoy "6" (FLR)
Y-42	At Newport News Channel Light Buoy "8" (FLR)

January 9, 1950

APPENDIX III

Preliminary Report Hampton Flats Section

Survey of Hampton Roads Shellfish Areas
Preliminary Report Hampton Flats Section

Public Health Engineer Russell S. Smith
February 23, 1950

General

The shallow water areas on the north side of Hampton Roads from Newport News Point northeast to Old Point Comfort are considered the most valuable oyster growing sections in the Hampton Roads area. Much of the Hampton Flats area is divided into beds leased to oystermen and used for growing oysters from seed to market size. Since September 1926 the taking of oysters for direct marketing from this area has been prohibited. For the past twenty-five years the area has been used to grow oysters from seed stock to market size and then all oysters have had to be transplanted into approved waters for a period of at least 14 days when the water temperature is consistently above 50°F. This transplanting results in increased costs and a certain percentage of loss.

Sanitary Survey

General

On the lower portion of the Peninsula in Warwick and Elizabeth City Counties and the incorporated communities of Newport News, Hampton and Phoebus is a population estimated at 125,000, most of whom are tributary to the waters of Hampton Roads.

Raw Sewage Discharge

There are only four points on the Lower Peninsula south of the mouth of the Warwick River where sewered populations not tributary to the Boat Harbor Plant of the Hampton Roads Sanitation District discharge sewage regularly. At the east end of the James River Bridge, located between the north limits of Newport News and Hilton Village, there are two housing developments with a total estimated population of 4,800 discharging effluent from an inadequate septic tank into the James River. This discharge is 5 miles northwest of Newport News Point and there is no evidence that it has a detrimental effect on the quality of the water on Hampton Flats east of Newport News Point. Diversion of this discharge to the Boat Harbor Treatment Plant is a primary concern of the Sanitation District and it is anticipated that this will be accomplished this summer. There is a small population, probably not exceeding 400, that discharges raw sewage into the upper reaches of Mill Creek northwest of the Fort Monroe Reservation and approximately 2 1/2 miles from the outlet of Mill

Creek to Hampton Flats. This discharge apparently does not effect the quality of the water on Hampton Flats as ten samples taken at the outlet of the creek on ebb tide had a median coliform most probable number of 23 per 100 ml. An Elizabeth City County trunk sewer serving an estimated population of 6,000 in the area north of Hampton toward Langley Field discharges raw sewage into an arm of Hampton Creek. According to the Public Works Division of Elizabeth City County, it is hoped that this trunk sewer will be connected to the Sanitation District lines tributary to the Boat Harbor Plant by the end of the summer of 1950. Almost midway between Newport News Point and Old Point Comfort a population of 400 discharges sewage, either raw or with inadequate septic tank treatment, into Indian Creek. It appears improbable that this discharge will be connected to the Boat Harbor plant in the near future.

During the period of the survey there was but one recorded discharge of raw sewage from the facilities of the Sanitation District in the Hampton Flats area. On December 5 between 2 a.m. and 8 p.m. there were 500,000 gallons bypassed from the Claremont Pumping Station (west of Indian Creek) due to clogging in a float tube.

On the afternoon of December 28 approximately 1,500,000 gallons of primary treated, but unchlorinated, sewage was discharged at Boat Harbor plant in a period of three hours and twenty minutes because of lack of chlorine.

Treated Sewage Discharge

The Boat Harbor Sewage Treatment Plant of the Hampton Roads Sanitation District is located on Newport News Point. It provides primary treatment and chlorination to an average flow of 8 to 9 M.G.D. Sewage entering the plant passes through mechanically cleaned bar racks before reaching the pumps. Screenings are ground and returned to the sewage flow. The pumped sewage is discharged to the channel leading to mechanically cleaned grit chambers and then flows by gravity through the rectangular settling tanks with mechanical sludge rakes and skimmers to the outfall. The sludge is digested in two digesters in series, the first of which is heated. Digested sludge is elutriated and filtered on vacuum filters. Chlorine may be applied either to the settling tank effluent (relying on a computed average detention period in the outfall of 15 minutes) or between the bar racks and the pumps. During the period of the survey all chlorine was applied to the sewage before pumping and an endeavor was made to carry a chlorine residual through the settling tanks. Previous to December 1 chlorinator capacity was insufficient to allow application of enough chlorine to satisfy the demand of the strong day flow sewage. About December 1 an additional chlorinator was installed and chlorine residuals were carried through the settling tanks at most times. Flows and chlorine application are given on the following page.

Month	Avg. Daily Flow M.G.D.	Avg. Chlorine Applied ppm
November	9.5	17.5
December	8.4	26.4
January	8.0	25.1

During December and January bacteriological samples were taken of the plant effluent five days a week and coliform M.P.N. determined. Samples were taken and chlorine residuals were recorded at 2 a.m., 4 a.m. and 6 a.m. and the three samples composited into a "minimum flow" sample. Similar samples were taken at 10 a.m., noon and 2 p.m. and composited into a "maximum flow" sample. A summary of results is given below:

	December	January
Coli M.P.N. per 100 ml.		
Maximum	23,000	+110,000
Median	-30	-30
Percent over 10,000	3	10
Chlorine residuals		
Percent less than 0.1	3	15

Bacteriological Results

A tabulation of the bacteriological results obtained on the water samples taken on Hampton Flats is presented in the attached Tables 1 and 2. A total of 45 sampling points were used and from 5 to 40 samples were taken from each point. At most points, 18 to 25 samples were taken. The results are arranged to show for each sample point the maximum, minimum and median M.P.N. for the periods prior and subsequent to December 1 and similar data for ebb tide, flood tide and all samples for the entire survey.

It will be noted that on the basis of all samples taken only one sample point on Hampton Flats (V-41) had a median coliform M.P.N. in excess of 43 per 100 ml. This point is located in a trough or depression leading northeast from the sewage plant outfall and had a median M.P.N. of 93. It is of interest to note that previous to December 1, when adequate chlorination was established, only six points had medians in excess of 70 per 100 ml. Three of these points were southwest of a line

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perpendicular to shore at Salter Creek and one was in the main channel and not on the flats. In general, the improvement in water quality due to improved chlorination was most evident southwest of a line drawn through the "watch house" and a brick hospital 800 yards northeast of Salter Creek, although after December there was a marked reduction in the maximum M.P.N. observed northwest of this line.

As is to be expected, the median MPN of ebb tide samples for the entire survey show that residual bacterial pollution in the sewage treatment plant effluents is carried further over the flats on ebb tide than on flood or all tides. Examination of data for ebb tide samples prior to December 1 (not presented here in detail) show that with inadequate chlorination of sewage plant effluent, median coliform M.P.N. in excess of 70 per 100 ml existed as far northeast as a line perpendicular to shore midway between Salter and Indian Creeks.

Conclusions

The bacteriological quality of the waters on Hampton Flats as shown by median coliform M.P.N. results for the entire survey period are well within the limiting standard for approved areas for shellfish taking with the exception of a small area about 1,500 yards northeast of Newport News Point. Bacteriological results of plant effluent samples and chlorination records indicate efficient and careful control of sewage treatment.

The rating of any area as "approved" or "restricted" for shellfish taking depends not only on bacteriological results in the area but on considered judgement concerning the actual or potential hazards involved. In the Hampton Flats area any decision concerning the possibility of reopening any portion of the area must consider the existing sewage discharges to Hampton and Indian Creeks. Consideration of these discharges near Indian Creek should not be opened until these sewage flows have been diverted to the sewage treatment plant.

In any area where the water quality is so evidently dependent upon the bacteriological quality of sewage plant effluent, any decision concerning opening of all or a part of the area must necessarily be dependent on the reliance that can be placed upon the ability and integrity of the operating personnel, together with reasonable standards of effluent to be met and the establishment of adequate safeguards against treatment interruptions and breakdowns.

It is believed that under present conditions in this area that no section within 3,600 yards of the sewage treatment plant outfall should be considered as an approved area. The established restriction line should be plainly and permanently marked with an adequate number of spar buoys of a distinctive color (possibly orange) to clearly delineate the approved area. Standards for bacteriological quality of plant effluent should be established and sufficient composite samples should be taken and correlated with chlorine residual readings of the effluent to ensure that these standards are being met. Requirements must be established for immediate reporting of any interruption of plant operation (causing bypassing of untreated sewage) or any interruption in effluent chlorination to all interested parties (State Board of Health, Commission of Fisheries, and all oyster growers having leased beds in the area). Hourly readings of chlorine residual should be made and kept on record for inspection. If and when satisfactory equipment for continuous recording of residual chlorine in sewage is developed, such equipment should be installed to provide a continuous, automatic record of the residual in the effluent reaching the outfall.

It is suggested that the standard of bacteriological quality of the effluent might be stated as having a median coliform M.P.N. for any month not in excess of 500 per 100 ml based on not less than 16 composite samples per month and not more than 15 percent of the samples to have a coliform M.P.N. per 100 ml. in excess of 10,000. The objective of chlorination should be to maintain an effluent residual of 0.2 ppm with 0.1 ppm as a minimum and it should be required that not more than 10 percent of the hourly readings of residual chlorine in any month shall be less than 0.1 ppm.

TABLE I

Survey of Hampton Roads Shellfish Areas
Summary of Bacteriological Results
Hampton Flats

Sample Point	No. of Samples Collected			Coliform Most Probable Number per 100 ml.								
		Oct.-	Dec.-	All Samples			October-November			December - February		
	Total	Nov.	Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
K-30	22	5	17	15000	9.1	240	15000	75	+1100	2400	9.1	240
L-26	10	-	10	93	15	43	-	-	-	93	15	43
M-28	25	8	17	240	3.6	43	240	3.6	43	93	3.6	23
M-29	24	7	17	460	9.1	43	460	9.1	23	150	9.1	43
M-30	22	8	14	240	3.6	43	93	3.6	43	240	9.1	33
N-26	23	6	17	460	3.6	23	93	9.1	23	460	3.6	43
N-29	22	8	14	460	3.6	33	460	3.6	43	93	9.1	23
N-31	20	6	14	460	3.6	43	240	14	93	460	3.6	33
O-27	12	6	6	93	3.6	23	93	3.6	33	43	9.1	12
O-29	21	7	14	150	3.6	23	150	9.1	43	93	3.6	23
O-30	21	7	14	460	3.6	23	460	9.1	23	43	3.6	19
O-32	18	4	14	460	3.0	23	460	20	132	150	3.0	23
O-34	25	8	17	+1100	3.6	43	+1100	3.6	43	460	9.1	43
P-28	12	6	6	93	7.3	23	93	7.3	33	93	9.1	23
P-33	22	8	14	240	-3.0	23	240	3.0	43	150	-3.0	23
P-34	24	7	17	1100	-3.0	23	1100	9.1	23	93	-3.0	23
P-35	27	8	19	460	3.6	43	460	3.6	68	460	3.6	43
Q-30	13	6	7	93	9.1	23	93	23	43	43	9.1	9.1
Q-32	22	8	14	240	9.1	23	240	9.1	33	240	9.1	23
Q-36	26	8	18	1100	-3.0	23	1100	3.6	33	43	-3.0	19

TABLE I (con.)

Sample Point	No. of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			October - November			December - February		
	Total	Oct-Nov.	Dec. Feb.	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
Q-37	27	8	19	+1100	3.6	23	460	3.6	33	+1100	3.6	23
R-32	5	1	4	43	3.6	21	21	21	21	43	3.6	16
R-34	23	8	15	240	7.3	23	240	7.3	43	93	15	23
R-37	27	9	18	1100	-3.0	23	1100	-3.0	23	150	-3.0	23
R-38	28	9	19	+1100	3.6	43	+1100	3.6	43	1100	9.1	43
S-32	15	6	9	93	3.0	23	93	23	23	93	3.0	23
S-35	26	8	18	1100	3.6	23	1100	9.1	122	43	3.6	23
S-38	29	9	20	460	3.6	23	460	3.6	23	160	3.6	23
T-35	15	7	8	1100	9.1	23	1100	23	43	75	9.1	23
T-36	28	9	19	1100	3.6	23	1100	23	43	460	3.6	23
T-38	27	9	18	1100	3.6	23	+1100	7.3	43	240	3.6	23
T-40	28	8	20	+1100	3.6	43	+1100	3.6	68	240	3.6	33
U-37	15	6	9	1100	3.6	43	1100	43	93	93	3.6	23
U-39	28	9	19	4600	-3.0	43	4600	21	43	240	-3.0	43
V-35	17	6	11	93	3.6	23	93	9.1	31	75	3.6	23
V-41	28	8	20	1100	11	93	1100	43	605	1100	11	75
W-36	17	6	11	+1100	9.1	23	+1100	14	68	43	9.1	23
W-38	14	4	10	460	9.1	43	460	23	97	460	9.1	43
W-39	18	7	11	1500	7.3	43	1500	23	460	93	7.3	23
W-40	24	6	18	+1100	9.1	23	+1100	9.1	43	93	9.1	23
X-36	19	5	14	460	9.1	23	460	9.1	93	150	15	23
X-42	40	12	28	4600	9.1	43	4600	23	335	240	9.1	41
X-43	22	8	14	+1100	7.3	68	1500	23	137	+1100	7.3	68
Y-40	20	5	15	+1100	9.1	43	+1100	43	93	240	9.1	23
Y-42	19	9	10	1100	9.1	43	1100	23	43	93	9.1	23

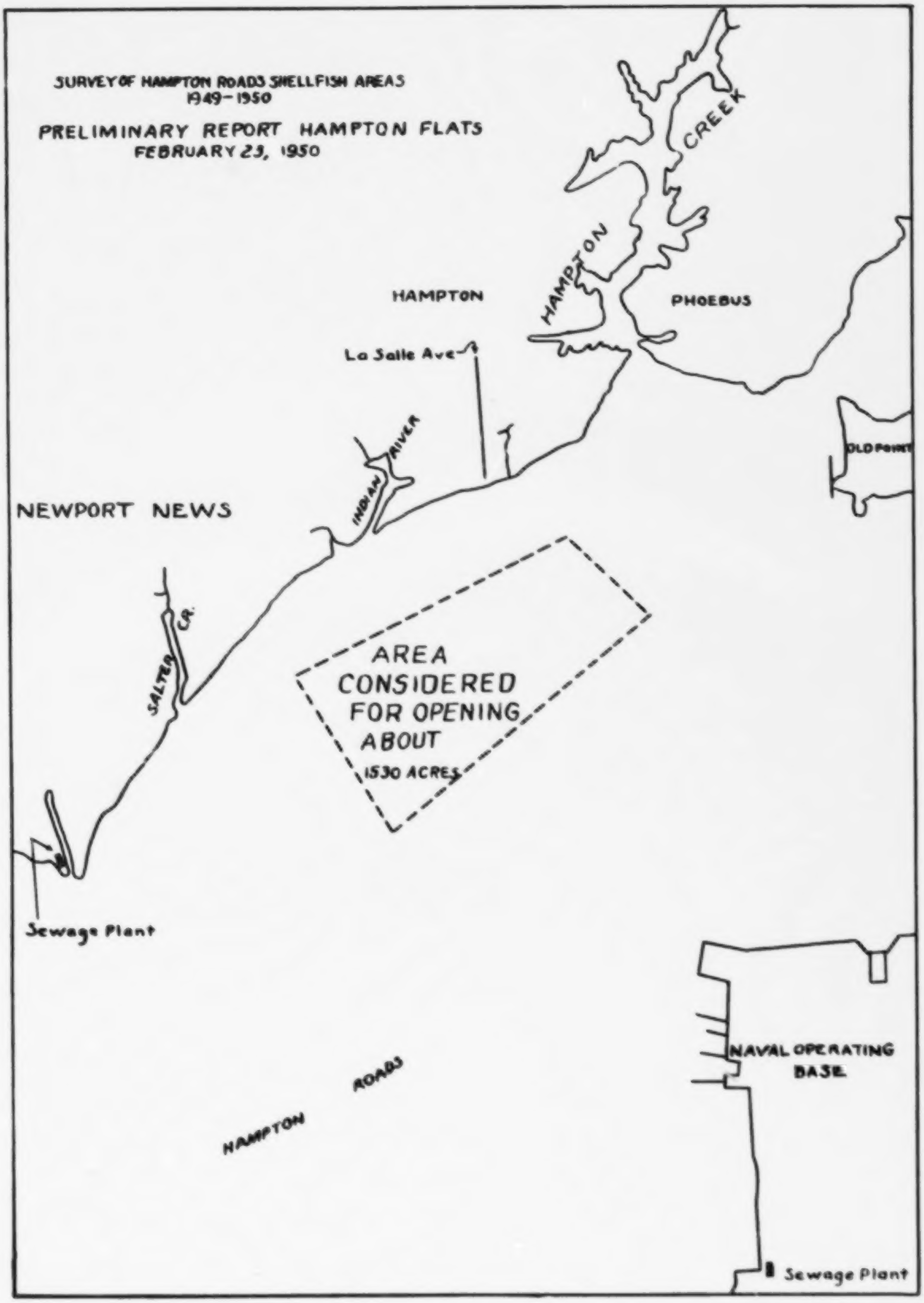
TABLE 2

Survey of Hampton Roads Shellfish Areas
Summary of Bacteriological Results
Hampton Flats

Sample Point	No. of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
K-30	22	8	14	15000	9.1	240	2400	9.1	240	15000	23	375
L-26	10	3	7	93	15	43	43	23	39	93	15	43
M-28	25	9	16	240	3.6	43	93	3.6	43	240	3.6	33
M-29	24	9	15	460	9.1	43	150	9.1	43	460	23	43
M-30	22	6	16	240	3.6	43	240	23	33	240	3.6	43
N-26	23	7	16	460	3.6	23	460	9.1	93	93	3.6	23
N-29	22	6	16	460	3.6	33	93	23	43	460	3.6	23
N-31	20	6	14	460	3.6	43	460	3.6	33	240	7.3	43
O-27	12	5	7	93	3.6	23	93	15	23	93	3.6	9.1
O-29	21	6	15	150	3.6	23	150	9.1	68	150	3.6	23
O-30	21	6	15	460	3.6	23	43	3.6	23	460	3.6	23
O-32	18	5	13	460	3.0	23	93	15	23	460	3.0	23
O-34	25	9	16	+1100	3.6	43	460	9.1	23	+1100	3.6	43
P-28	12	5	7	93	7.3	23	93	7.3	23	93	9.1	23
P-33	22	6	16	240	-3.0	23	43	-3.0	6.4	240	3.0	33
P-34	24	8	16	1100	-3.0	23	93	-3.0	16	1100	9.1	23
P-35	27	10	17	460	3.6	43	460	3.6	23	460	3.6	75
Q-30	13	6	7	93	9.1	23	93	9.1	23	43	9.1	23
Q-32	22	7	15	240	9.1	23	23	9.1	23	240	9.1	43
Q-36	26	8	18	1100	-3.0	23	43	-3.0	23	1100	3.6	23

TABLE 2 (Con.)

Sample Point	No. of Samples Collected			Coliform Most Probable Number per 100 ml.								
				All Samples			Flood Tide			Ebb Tide		
	Total	Flood Tide	Ebb Tide	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
Q-37	27	11	16	+1100	3.6	23	460	3.6	15	+1100	9.1	33
R-32	5	1	4	43	3.6	21	21	21	21	43	3.6	16
R-34	25	8	15	240	7.3	23	43	23	23	240	7.3	23
R-37	27	9	18	1100	-3.0	23	150	-3.0	23	1100	-3.0	23
R-38	28	12	16	+1100	3.6	43	1100	3.6	23	+1100	3.6	43
S-32	15	7	8	93	3.0	23	93	23	23	93	3.0	22
S-35	26	8	18	1100	3.6	23	240	9.1	23	1100	3.6	23
S-38	29	14	15	460	3.6	23	150	3.6	23	460	3.6	39
T-35	15	6	9	1100	9.1	23	150	23	59	1100	9.1	23
T-38	28	11	17	1100	3.6	23	43	23	23	1100	3.6	43
T-38	27	10	17	+1100	3.6	23	93	7.3	23	+1100	3.6	43
T-40	28	14	14	+1100	3.6	43	150	3.6	33	+1100	9.1	93
U-37	15	7	8	1100	3.6	43	93	15	43	1100	3.6	58
U-39	28	11	17	4600	+3.0	43	75	-3.0	23	4600	9.1	75
V-35	17	10	7	93	3.6	23	93	15	23	93	3.6	23
V-41	28	14	14	1100	11	93	1100	15	59	1100	11	240
W-36	17	9	8	+1100	9.1	23	240	14	23	+1100	9.1	33
W-38	14	7	7	460	9.1	43	460	23	43	460	9.1	43
W-39	18	8	10	1500	7.3	43	460	7.3	41	1500	9.1	59
W-40	24	10	14	+1100	9.1	23	93	9.1	23	+1100	9.1	23
X-36	19	11	8	460	9.1	23	460	9.1	23	240	15	33
X-42	40	20	20	4600	9.1	43	+1100	9.1	59	4600	9.1	43
X-43	22	10	12	+1100	7.3	68	+1100	23	93	1100	7.3	43
Y-40	20	12	8	+1100	9.1	43	+1100	9.1	43	93	9.1	33
Y-42	19	11	8	1100	9.1	43	1100	9.1	39	240	9.1	68



SURVEY OF HAMPTON ROADS SHELLFISH AREAS
1949-1950

PRELIMINARY REPORT HAMPTON FLATS
FEBRUARY 23, 1950

HAMPTON CREEK
HAMPTON
PHOEBUS
La Salle Ave
INDIAN RIVER
OLD POINT
NEWPORT NEWS
SALTER CR.
AREA CONSIDERED FOR OPENING ABOUT 1530 ACRES
Sewage Plant
NAVAL OPERATING BASE
HAMPTON ROADS
Sewage Plant